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AD____________________
RDTE PROJECT NO.
AVSCOM PROJECT NO. 71-24
USAASTA PROJECT NO. 71-24

EVALUATION OF THE OH-58A HELICOPTER WITH AN ALLISON 250-C20 ENGINE

FINAL REPORT

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DECEMBER 1972

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UNITED STATES ARMY AVIATION SYSTEMS TEST ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA 93523

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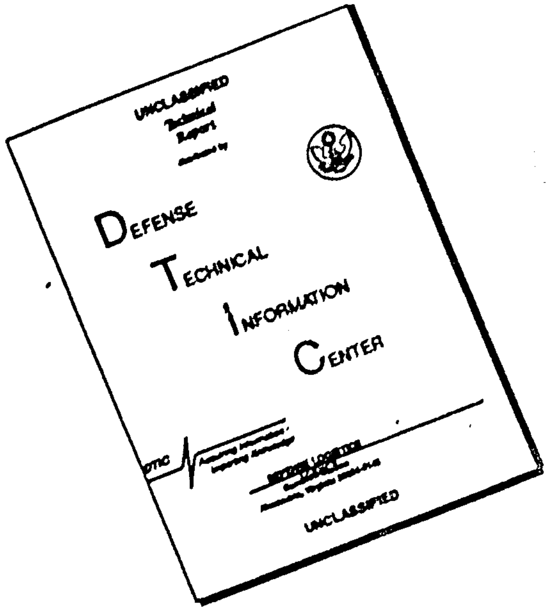

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UNITED STATES ARMY AVIATION SYSTEMS TEST ACTIVITY
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FOREWORD

Technical assistance was provided by the engine manufacturer, Detroit Diesel Allison Division of General Motors.

ABSTRACT

The United States Army Aviation Systems Test Activity conducted a limited performance and handling qualities evaluation of the Bell Helicopter Company model OH-58A helicopter with an Allison 250-C20 engine installed. The evaluation was conducted at Edwards Air Force Base, and Bishop, California, during the period 22 September 1971 to 7 January 1972. Twenty-five flights, 21.2 productive test hours, were required for the evaluation. Test results obtained with the Allison 250-C20 engine were compared with those previously obtained with the standard T63-A-700 engine. The primary performance improvement noted was an increase in out-of-ground-effect hover ceiling at a 3000-pound gross weight to 10,000 feet from 4600 feet. The long-range cruise airspeed was increased to 111 knots true airspeed from 104 knots true airspeed at a 5000-foot density altitude and a 3000-pound gross weight. The increased engine power did not significantly increase the service ceiling over the basic OH-58A at identical gross weights. One shortcoming, insufficient left directional control at 35 knots true airspeed in right sideward flight, was noted. Within the scope of the test, the performance of the OH-58A helicopter with the Allison 250-C20 engine was improved over the basic OH-58A helicopter. Handling qualities were essentially unchanged.

TABLE OF CONTENTS

Page

APPENDIXES

DISTRIBUTION

INTRODUCTION

BACKGROUND

1. The 250-C20 gas turbine engine is a growth version of the T63-A-700 engine manufactured by the Detroit Diesel Allison Division of General Motors Corporation. Engineering flight tests of the Bell Helicopter Company model OH-58A helicopter with the T63-A-700 engine were previously conducted by the United States Army Aviation Systems Test Activity (USAASTA) (refs 1 and 2, app A). The United States Army Aviation Systems Command (AVSCOM) directed USAASTA to conduct an evaluation of the OH-58A helicopter with the 250-C20 engine installed (refs 3 and 4).

TEST OBJECTIVE

2. The objective of this test was to evaluate the performance and handling qualities of the OH-58A helicopter with an Allison 250-C20 engine installed.

DESCRIPTION

3. The OH-58A is a single-main-rotor, turbine-powered, light observation helicopter, manufactured by Bell Helicopter Company, Fort Worth, Texas. The main rotor is a two-bladed, semirigid, teetering type; and the tail rotor is a two-bladed, semirigid, delta-three hinge type. The cockpit configuration is two place (pilot and copilot/observer), and the cargo compartment has provisions for seating two passengers. Dual flight controls are provided with cyclic and collective controls boosted, and the tail rotor controls unboosted. The main landing gear is a fixed, energy-absorbing, skid type. For this testing, the helicopter was powered by an Allison 250-C20 free gas turbine engine with a military rated power of 400 shaft horsepower (shp) derated to the transmission power limit of 270 shp (maximum continuous) with a takeoff power limit of 317 shp (5 minutes). A detailed description of the OH-58A helicopter is contained in the operator's manual (ref 5, app A).

SCOPE OF TEST

4. Flight testing of the OH-58A helicopter with the 250-C20 engine installed was conducted at Edwards Air Force Base, and Bishop, California, during the period 22 September 1971 through 7 January 1972 by USAASTA personnel. Twenty-five test flights consisting of 21.2 productive hours were conducted under the conditions listed in table 1.

Table 1. Test Conditions.[1]

Test	Calibrated Airspeed (kt)	Gross Weight (lb)	Density Altitude (ft)	Average Outside Air Temperature (°C)	Average Center of Gravity (in.)
Hover performance[2]	Zero	2463 to 3209	10,300 to 11,700	5	108.0 (fwd)
Level flight performance	20 to 93	3150 to 3200	8,350 to 14,170	-6.74 to -1.34	107.1 (fwd)
Climb performance	38 to 50	3213 (takeoff)	1,200 to 16,800	NA	107.0 (fwd)
Sideward flight	Zero to [3]35	2460 to 2785	9,920 to 11,340	1.9 to 13.6	109.0 (mid)
Trim control positions	32 to 103	3115 to 3200	7,750 to 14,420	-6.7 to 2.0	107.1 (fwd) 111.4 (aft)
Static longitudinal stability	61, 80, 102	3115	7,750	2.0	111.4 (aft)
Autorotational entry characteristics	Zero to 117	2570 to 3215	6,000	19	106.8 (fwd)
Engine governing characteristics	80	3140	7,000	12	107.0 (fwd)

[1]Rotor speed: 354 rpm.
[2]Out of ground effect (50-foot skid height).
In ground effect (4-foot skid height).
[3]Knots true airspeed.

5. Test results were compared to those previously reported for the OH-58A helicopter with the T63-A-700 engine (refs 1 and 2, app A). Flight limitations contained in the operator's manual (ref 5) and the safety-of-flight release (app B) were observed during the test.

METHODS OF TEST

6. Flight test methods used are briefly described in the Results and Discussion section of this report. Performance data were manually recorded from cockpit instrumentation. All performance data are based on specification engine performance (ref 6, app A) adjusted for T63-A-700 installation losses (ref 1). Flying qualities data were recorded by an oscillograph located in the cargo/passenger compartment. A detailed list of test instrumentation is contained in appendix C.

CHRONOLOGY

7. The chronology of the OH-58A helicopter with Allison 250-C20 engine evaluation is as follows:

Test directive received	24	June	1971
Allison 250-C20 engine installed	16	September	1971
Flight tests started	22	September	1971
Flight tests completed	7	January	1972

RESULTS AND DISCUSSION

GENERAL

8. A limited performance and handling qualities evaluation of the OH-58A helicopter with an Allison 250-C20 engine installed was conducted by the United States Army Aviation Systems Test Activity personnel. Performance testing included hover, level flight, and climb performance. Handling qualities were evaluated during sideward flight, forward flight, and autorotational entries. Primary performance improvement over the standard T63-A-700 engine was an increase in out-of-ground-effect hover ceiling to 10,000 feet from 4600 feet. The specific range was essentially unchanged, but there was an increase of the long-range cruise airspeed to 111 knots true airspeed from 104 knots true airspeed at a 5000-foot density altitude and a 3000-pound gross weight. The climb capability of the aircraft was not limited by engine power available. Instead, an apparent maximum rotor thrust limit which occurred at a 6800-foot density altitude, a 3150-pound gross weight, and a thrust coefficient of 0.00531 prevented climbing to higher altitudes. One shortcoming, insufficient left directional control at 35 knots true airspeed in right sideward flight, was noted. Within the scope of the test, the performance of the OH-58A helicopter with the Allison 250-C20 engine was improved over the basic OH-58A helicopter, while handling qualities were essentially unchanged.

PERFORMANCE

9. Performance testing of the OH-58A helicopter with the Allison 250-C20 engine was conducted at a hover, in level flight, and in climbs. Performance test results were compared to results obtained with the previously tested T63-A-700 engine. The out-of-ground-effect (OGE) hover ceiling was increased to 10,000 feet from 4600 feet. The specific range was essentially unchanged, but there was an increase of the long-range cruise airspeed to 111 KTAS from 104 KTAS at a 5000-foot density altitude and a 3000-pound gross weight. A service ceiling of 16,800 feet at a 3200-pound gross weight was obtained during climb testing. Within the scope of the test, the performance characteristics of the OH-58A helicopter with the Allison 250-C20 engine are improved over the basic OH-58A helicopter.

Hover Performance

10. Hover performance tests were conducted at skid heights of 4 feet in ground effect (IGE), and 50 feet OGE under the conditions shown in table 1. The free-flight hover method was used to determine hover performance. Skid height was measured by visual reference to a measured weighted cord attached to the right skid. Incremental amounts of ballast were added to the helicopter until either the engine temperature or transmission power limit was reached. Test results are presented in figures 1 and 2, appendix D.

11. A comparison of the standard-day hover performance with the 250-C20 and T63-A-700 engine is presented as figure A. The OH-58A with the 250-C20 engine installed had an increase in OGE hover ceiling to 10,000 feet from 4600 feet at a gross weight of 3000 pounds. The increased hover performance of the OH-58A with the 250-C20 engine enhances its operational capability. Within the scope of the test, the hover performance of the OH-58A helicopter with the 250-C20 engine is improved over the basic OH-58A helicopter.

Level Flight Performance

12. Level flight performance tests were conducted to determine power required and associated fuel flow as a function of airspeed. In addition, specific range, long-range cruise airspeed, and maximum airspeed in level flight were determined. Test conditions are presented in table 1. Data were obtained in stabilized coordinated level flight using the referred gross weight method of test. Test results are presented in figures 3 through 6, appendix D. Level flight range summaries are presented as figures 7 through 9. For altitudes at sea level, 5000, and 10,000 feet, long-range cruise airspeed increased for the 250-C20 engine. There was essentially no change in the specific range. Within the scope of this test, the level flight performance of the OH-58A helicopter with the 250-C20 engine is improved over the basic OH-58A helicopter.

Climb Performance

13. Continuous climbs were conducted from a 1200-foot density altitude to the service ceiling under the conditions listed in table 1. The climb airspeeds used were determined from previous climb tests (ref 1, app A). Test results are presented in figure 10, appendix D.

14. An abrupt reduction in the rate of climb accompanied by intense airframe vibrations was noted above a density altitude of 16,000 feet. Attempts to increase the rate of climb at the service ceiling of 16,800 feet by varying airspeed from the scheduled 34 knots indicated airspeed (KIAS) had no effect except that vibrations increased markedly at higher airspeed followed by immediate altitude losses. At slower airspeeds the vibrations decreased, but again the helicopter lost altitude. The sharp decrease in rate of climb and the vibrations encountered are attributed to an apparent rotor thrust limit which occurred at a 16,800-foot density altitude, a 3150-pound gross weight, and a C_T of 0.00531. Despite an increase in power available with the 250-C20 engine, the service ceiling is not significantly increased over the basic OH-58A at identical gross weights.

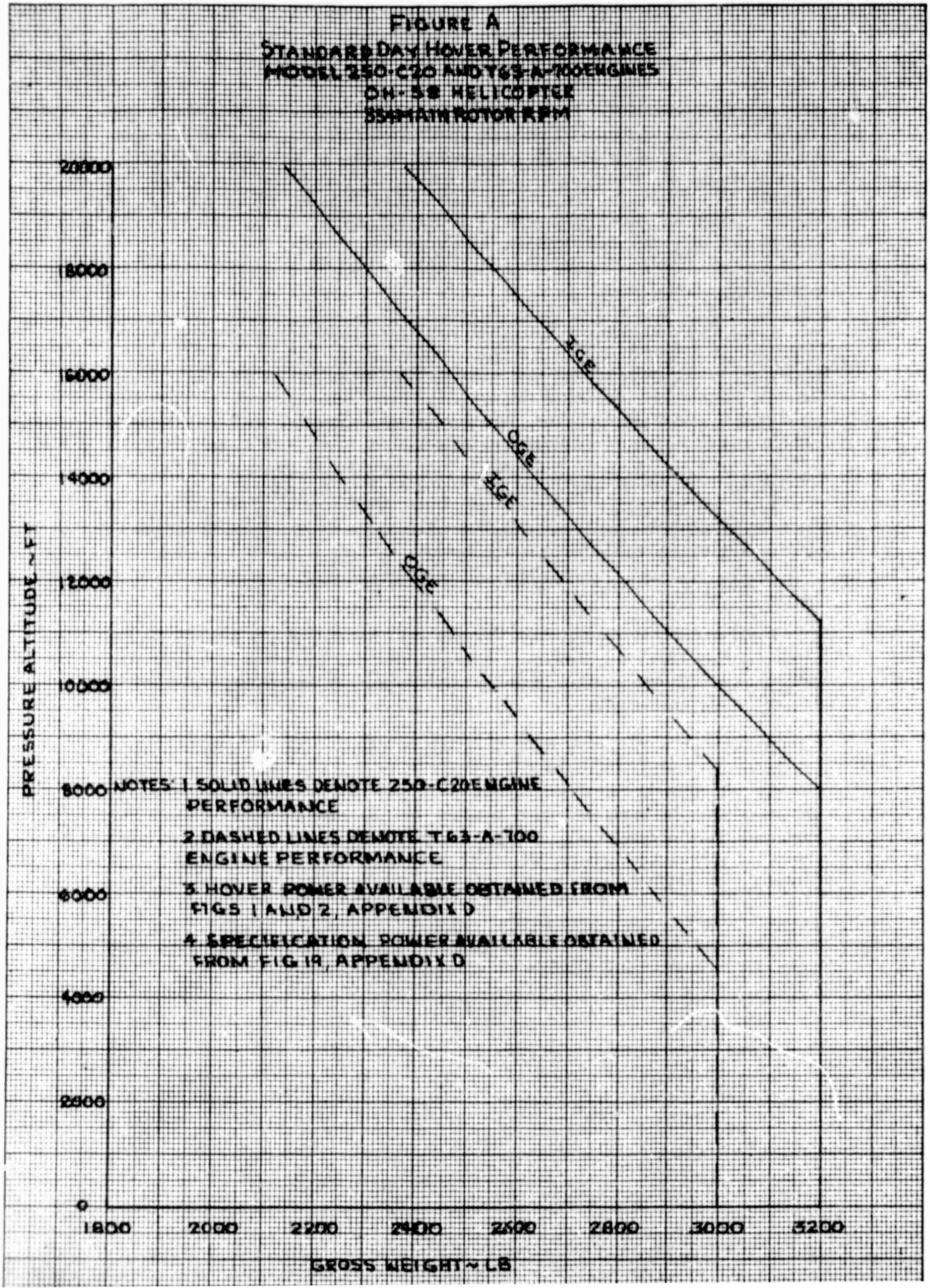


FIGURE A
STANDARD DAY HOVER PERFORMANCE
MODEL 250-C20 AND T63-A-700 ENGINES
OH-58 HELICOPTER
354 MAIN ROTOR RPM
PRESSURE ALTITUDE ~ FT
GROSS WEIGHT ~ LB
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
1800
2000
2200
2400
2600
2800
3000
3200
IGE
OGE
IGE
OGE
NOTES: 1. SOLID LINES DENOTE 250-C20 ENGINE PERFORMANCE
2. DASHED LINES DENOTE T63-A-700 ENGINE PERFORMANCE
3. HOVER POWER AVAILABLE OBTAINED FROM FIGS 1 AND 2, APPENDIX D
4. SPECIFICATION POWER AVAILABLE OBTAINED FROM FIG 19, APPENDIX D

HANDLING QUALITIES

General

15. A limited handling qualities evaluation of the OH-58A helicopter with the Allison 250-C20 engine was conducted under day visual-flight-rules conditions. Sideward flight, forward flight, and autorotational entries were conducted, and the results were compared to those obtained with the standard T63-A-700 engine. One shortcoming, insufficient left pedal at 35 knots true airspeed in right sideward flight, was noted. Within the scope of this test, the handling qualities of the OH-58A helicopter with the Allison 250-C20 engine were essentially unchanged from the basic OH-58A helicopter.

Sideward Flight Characteristics

16. Sideward flight characteristics were evaluated at the conditions shown in table 1. Wind azimuths at 45, 90, and 135 degrees relative to the nose of the helicopter were used. These azimuths were considered critical due to previous data contained in reference 2, appendix A. Test results are presented in figure 11, appendix D.

17. Previous right sideward flight test at a C_T of 0.00343 resulted in a left pedal margin of 5 percent at 35 KTAS (ref 2, app A). Results of tests with the 250-C20 engine showed that at 35 KTAS, the directional control margin rapidly diminished with increased C_T's. In 35-KTAS right sideward flight at a C_T of 0.00392, the directional control margin was reduced to less than 2 percent. Although aircraft control could be maintained, there was not sufficient left directional control to counteract a lateral gust disturbance. However, at 30 KTAS, at least a 12-percent directional control margin remained. Directional control in 35-KTAS right sideward flight failed to meet the requirements of paragraph 3.3.4 of MIL-H-8501A. Insufficient left directional control in 35-KTAS right sideward flight is a shortcoming.

Control Positions in Trimmed Forward Flight

18. Control positions in trimmed forward flight were evaluated from 32 to 103 knots calibrated airspeed under the conditions shown in table 1. Test results are presented in figures 12 and 13, appendix D. For all test conditions, increasing forward longitudinal control movement was required for increased trim speed. The variation in longitudinal control position between autorotations and maximum-power climbs was approximately 1.2 inches.

19. Directional and lateral control positions varied less than 1 inch for a given configuration throughout the airspeed range tested. No significant variation in directional or lateral control positions was noted when transitioning from a maximum-power climb to an autorotation. The requirements of paragraphs 3.2.10.2 and 3.3.17 of MIL-H-8501A (ref 7, app A) were met. Within the scope of the

test, the control position characteristics of the OH-58A helicopter with the 250-C20 engine are essentially unchanged from the basic OH-58A helicopter.

Collective-Fixed Static Longitudinal Stability

20. Collective-fixed static longitudinal stability was evaluated under the conditions listed in table 1. The tests were conducted by initially trimming the helicopter at the desired airspeed and then stabilizing at slower and faster airspeeds while holding constant collective pitch. Test results are presented in figure 14, appendix D.

21. For the configurations tested, the aircraft possessed static longitudinal stability as evidenced by forward longitudinal control displacement for increased airspeed, and aft longitudinal control displacement for decreased airspeed from trim. Within the scope of the test, the collective-fixed static longitudinal stability of the OH-58A helicopter with the 250-C20 engine is essentially unchanged from the basic OH-58A helicopter.

Autorotational Characteristics

22. The response of the helicopter to simulated sudden engine failures was evaluated under the conditions shown in table 1. The aircraft was trimmed in balanced flight and with the controls fixed, the throttle was rapidly retarded to the flight-idle position (throttle chop). Recoveries were initiated at a minimum rotor speed of 304 rpm, a maximum pitch attitude of 30 degrees, or a maximum roll attitude of 45 degrees. Test results are presented in figures 15 and 16, appendix D. A true sudden engine failure could not be simulated by rapidly closing the throttle since the fuel control limited the engine deceleration. An engine torque decay time constant (time to 63 percent of initial value) of 1.1 second was measured for the 250-C20 engine, compared to a time constant of 0.6 second for the T63-A-700 engine. As a result of the larger engine torque decay time constant, the rate of rotor decay and aircraft reactions were not as great as those previously tested with the T63-A-700 engine (figs. 15 and 16). To determine the rate of rotor decay for a sudden engine failure, an analytical method was used with a time constant of zero. By assuming that the power coefficients (Cp's) before and after the throttle chop are equal, the following equation for rate of rotor decay can be derived:

$$\frac{d\Omega}{dt} = \frac{\dfrac{-I\ \Omega o^2}{Qo}}{t^2 + \left(\dfrac{2I\ \Omega o}{Qo}\right)(t) + \left(\dfrac{I\ \Omega o}{Qo}\right)^2}$$

Where: $\frac{d\Omega}{dt}$ = rate of rotor decay

I = main rotor inertia

t = time after engine failure

Ωo = initial main rotor speed

Qo = initial main rotor torque

This equation was solved for $d\Omega/dt$ at the following:

t = 1 second

I = 607 slug/ft^2

Ωo = 354 rev/min

Qo = from 1881 ft-lb to 4703 ft-lb

The results of this analysis show that at 100-percent main rotor torque a main rotor decay rate of 50 rpm per second (rpm/sec) would be encountered, compared to a measured main rotor decay rate of 23 rpm/sec (figs. 15 and 16). This decay rate would not allow a 2-second delay before lowering the collective, as specified in paragraph 3.5.5 of MIL-H-8501A for a minimum transient rotor speed of 304 rpm. No attempt was made to calculate the magnitude of the aircraft reactions for a sudden engine failure; however, they would be greater than those measured.

23. The reaction of the helicopter following the throttle chop was a slight nose-up pitch during the first second followed by a substantial nose-down pitching motion. In addition, a left roll and left yaw were observed in all instances. The roll rate increased with increasing forward airspeed, while the yaw rate decreased as airspeed was increased. Control effectiveness during the recovery phase was adequate to avoid unsafe rates, attitudes, or airspeeds. The aircraft responses to sudden engine failure with the 250-C20 engine were similar to those previously observed with the basic OH-58A helicopter.

MISCELLANEOUS TESTS

Engine Characteristics

24. Engine characteristics of the 250-C20 engine to include fuel flow and power available were determined from the engine manufacturer's specifications (ref 6, app A). A comparison of the power available for the 250-C20 and the T63-A-700 engine is presented in figure 17, appendix D. Engine fuel-flow data for the 250-C20 engine are presented in figure 18. Inlet and exhaust losses were determined from data previously obtained with the T63-A-700 engine (ref 1, app A).

Engine Governing Characteristics

25. Static and dynamic droop characteristics of the 250-C20 engine governor were evaluated under the conditions listed in table 1. Static tests were conducted by trimming the helicopter at 103-percent power turbine speed (N_2), and incrementally lowering and raising the collective. Dynamic characteristics were evaluated by rapidly moving the collective between maximum-power and minimum-power settings. Test results are presented in table 2 and figure B.

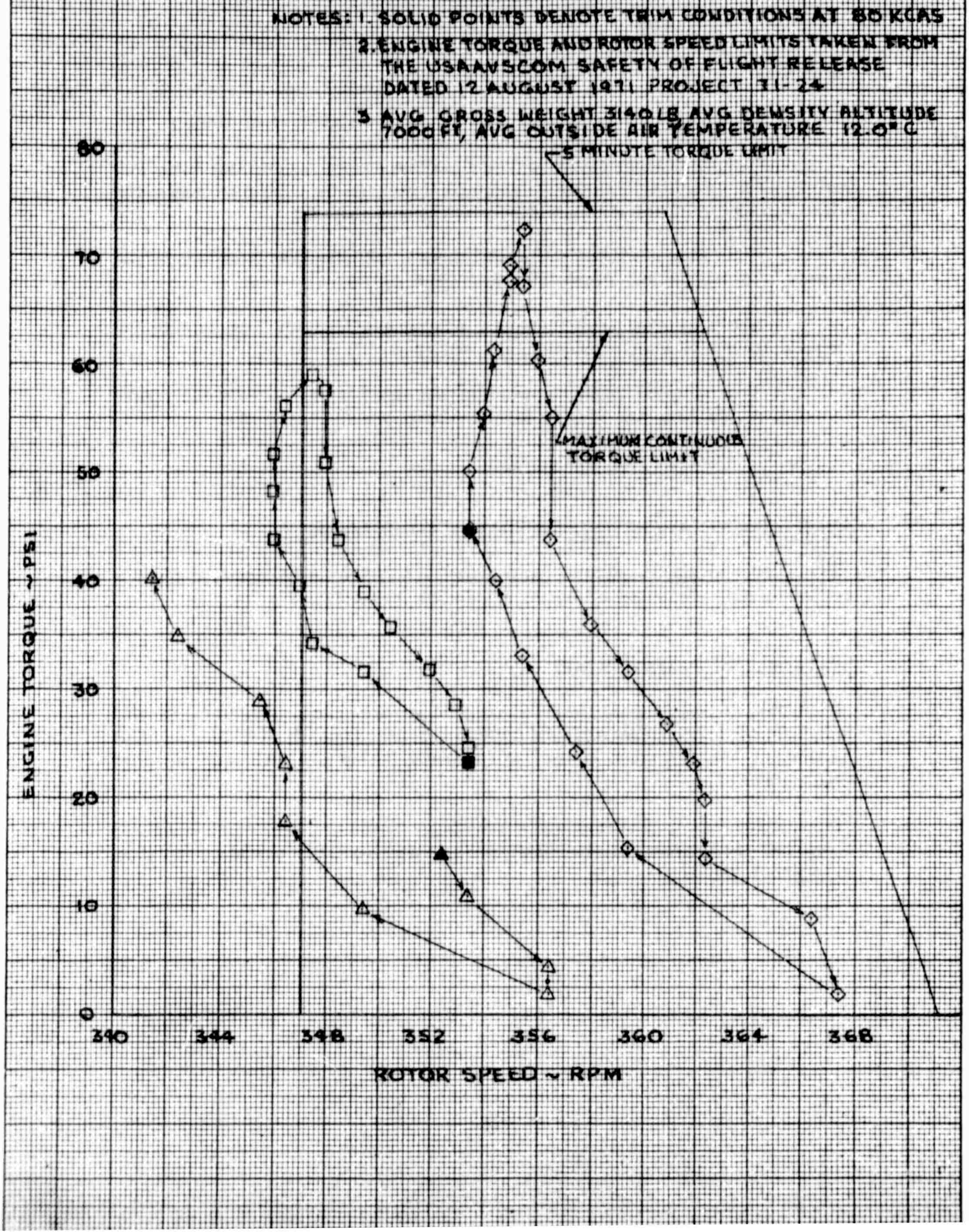
Table 2. Dynamic Droop Characteristics in Level Flight at 80 KCAS.[1]

Test Condition	Steady-State Engine Torque (psi)[2]	Steady-State Rotor Speed (rpm)	Transient Rotor Speed (rpm)
Trim to down collective	63 to 21	354 to 361	-- 367 (max)
Trim to up collective	21 to 64	361 to 353	-- 345 (min)

[1]OH-58 helicopter with Allison 250-C20 engine.
[2]Pounds per square inch.

26. Rotor speed during the engine governing systems tests did not exceed the output shaft speed limit. A 12-rpm underspeed occurred during full-up collective positioning, but was not considered a critical factor. Within the scope of this test, the engine governing characteristics of the 250-C20 engine are satisfactory for Army use.

FIGURE 5
STATIC DROOP CHARACTERISTICS
MODEL 250-C20 ENGINE
OH-58 USA S/N68-16706



CONCLUSIONS

GENERAL

27. The following conclusions were reached upon completion of testing.

a. Within the scope of this test, the performance of the OH-58A helicopter with the Allison 250-C20 engine was improved over the basic OH-58A helicopter, while handling qualities were essentially unchanged (para 8).

b. The out-of-ground-effect hover ceiling at a 3000-pound gross weight was increased to 10,000 feet from 4600 feet (para 11).

c. The long-range cruise airspeed was increased to 111 knots calibrated airspeed from 104 knots calibrated airspeed (para 12).

d. The increased engine power did not significantly increase the service ceiling over the basic OH-58A at identical gross weights (para 14).

e. One shortcoming was noted.

SHORTCOMING AFFECTING MISSION ACCOMPLISHMENT

28. Insufficient left directional control at 35 KTAS in right sideward flight is a shortcoming, correction of which is desirable (para 17).

SPECIFICATION COMPLIANCE

29. Within the scope of this test, the OH-58A helicopter with the 250-C20 engine failed to meet paragraph 3.3.4 of military specification MIL-H-8501A, in that insufficient left directional control was available during 35-KTAS right sideward flight (para 17).

30. A sudden engine failure at maximum torque would not meet paragraph 3.5.5 of military specification MIL-H-8501A, in that collective delay would be less than 1 second (para 22).

RECOMMENDATIONS

31. The shortcoming, correction of which is desirable, should be corrected as soon as possible.

32. The test results should be incorporated in the operator's manual if the OH-58A helicopter with the 250-C20 engine is released for operational use.

APPENDIX A. REFERENCES

1. Final Report, USAASTA, Project No. 68-30, *Airworthiness and Flight Characteristics Test, Production OH-58A Helicopter, Unarmed and Armed with XM27E1 Weapon System, Performance*, September 1970.

2. Final Report, USAASTA, Project No. 68-30, *Airworthiness and Flight Characteristics Test, Production OH-58A Helicopter, Unarmed and Armed with XM27E1 Weapon System, Stability and Control*, October 1970.

3. Letter, AVSCOM, AMSAV-R-F, subject: Evaluation of Allison 250-C20 Engine in OH-58 Helicopter, Project No. 71-24, 24 June 1971.

4. Letter, AVSCOM, AMSAV-EF, subject: Evaluation of Allison 250-C20 Engine in OH-58 Helicopter (revision of letter dated 24 June 1971), Project No. 71-24, 6 August 1971.

5. Technical Manual, TM 55-1520-228-10, *Operator's Manual, Army Model OH-58A Helicopter*, 13 October 1970.

6. Model Specification, Detroit Diesel Allison Division of General Motors Corporation, No. C800-C, *Commercial Turboshaft Engine, Model 250-C20*, 1 September 1971.

7. Military Specification, MIL-H-8501A, *Helicopter Flying and Ground Handling Qualities; General Requirements For*, September 1961, with Amendment 1, 3 April 1962.

APPENDIX B. SAFETY-OF-FIGHT RELEASE

DEPARTMENT OF THE ARMY
US ARMY AVIATION SYSTEMS COMMAND
PO BOX 209, ST. LOUIS, MO 63166

AMSAV-EF

12 AU[illegible]

SUBJECT: Safety of Flight Release for USAAVSCOM/USAASTA Project No. 71-24

Commanding Officer
U.S. Army Aviation
Systems Test Activity
ATTN: SAVTE-P

1. This letter constitutes a safety of flight release, in accordance with AMCR 70-33, for USAASTA to conduct USAAVSCOM/USAASTA Project No. 71-24, Evaluation of the Allison 250-C20 Engine in the OH-58A Helicopter.

2. The flight envelope and operating limitations for conduct of Project No. 71-24 shall be in accordance with the TM55-1520-228-10, OH-58A Operators Manual, except as noted below:

a. Instrument Markings

(1) Engine Oil Pressure Module

Double green arc	115 - 130 psig
Single green arc	90 - 115 psig
Yellow arc	50 - 90 psig
Red line at	50 psig

(2) Torquemeter

Red line at	74 3 psig - max
Yellow arc	63.0 - 74.3 psig - 5 min. oper
Green arc	0 - 63.0 psig - continuous oper

(3) Gas Produce Tach

Green arc	60% - 104%
Red line at	104% - max

NOTE:

Transient Limit 105% (max of 15 sec)

(4) Turbine Outlet Temperature

Red line at	793°C - max (30 min. limit below 40°C O.A.T. and 5 min. limit above 40°C O.A.T.)
Yellow arc	737°C - 793°C - starting and transient
Green arc	330°C - 737°C continuous oper.

NOTE:

Transient limit 793°C to 843°C during power transients (6 sec. max)

Maximum for starting 793°C to 927°C (10 sec. max)

b. Center of Gravity Limitations - The maximum center of gravity limitations are shown in figure 1 (Incl 1).

c. Weight Limitations - 3200 pounds maximum gross weight.

d. Vertical Load Factor at the c.g. - The maximum load factor versus gross weight is shown in figure 2 (Incl 2).

e. Airframe and engine torque and output shaft (N_2) speed limits are shown in figure 3 (Incl 3).

f. Fatigue lives are the same as the standard OH-58A except for the pylon support link which has a 4800 hour retirement life for the test configuration.

g. Ambient operating temperatures shall be limited to 100°F due to engine compartment cooling.

h. Special Instructions

(1) Engine starting procedure shall be the same as that for the standard OH-58A.

(2) During low power descents N_2 speeds up to 106% are authorized; as are transient N_2 speeds down to 98% upon power application for the purpose of evaluating engine governing characteristics.

AMSAV-EF 12 AUG 1971

SUBJECT: Safety of Flight Release for USAAVSCOM/USAASTA Project No. 71-24

3. This safety of flight release applies to the OH-58A/C20 resulting from the incorporation of the BHC retro-fit kit (P/N 206HA-108-1) and the Allison C20 engine in accordance with the retro-fit kit instructions.

4. Aircraft Logbook Entry:

a. In accordance with the provisions of TM 38-750, the following entries will be made on the DA Form 2408-13 and will be perpetuated on each form during the period of the test, or until superseded by another safety of flight release, or until the reason for limitation is removed, or until the appropriate -10 and 10CL manuals are revised to reflect the limitations as normal procedure.

(1) Block 17, "Test Aircraft - Operate within limitations prescribed in the inclosed SOFR, (date)".

(2) The above entry will be preceeded by the entry of a circled red X within block 16, and block 7 adjusted when appropriate.

b. An exact copy of this SOFR will be inserted into the aircraft logbook.

FOR THE COMMANDER:

Robert F. Forsyth

3 Incl
as

ROBERT F. FORSYTH
LTC, TC
Actg Chief, Flt Std & Qual Div
Directorate for RD&E

Copy furnished:
Commanding General
US Army Materiel Command
ATTN: AMCRD-FQ
AMCSF-A

FIGURE 1

GROSS WEIGHT - CENTER OF GRAVITY ENVELOPE

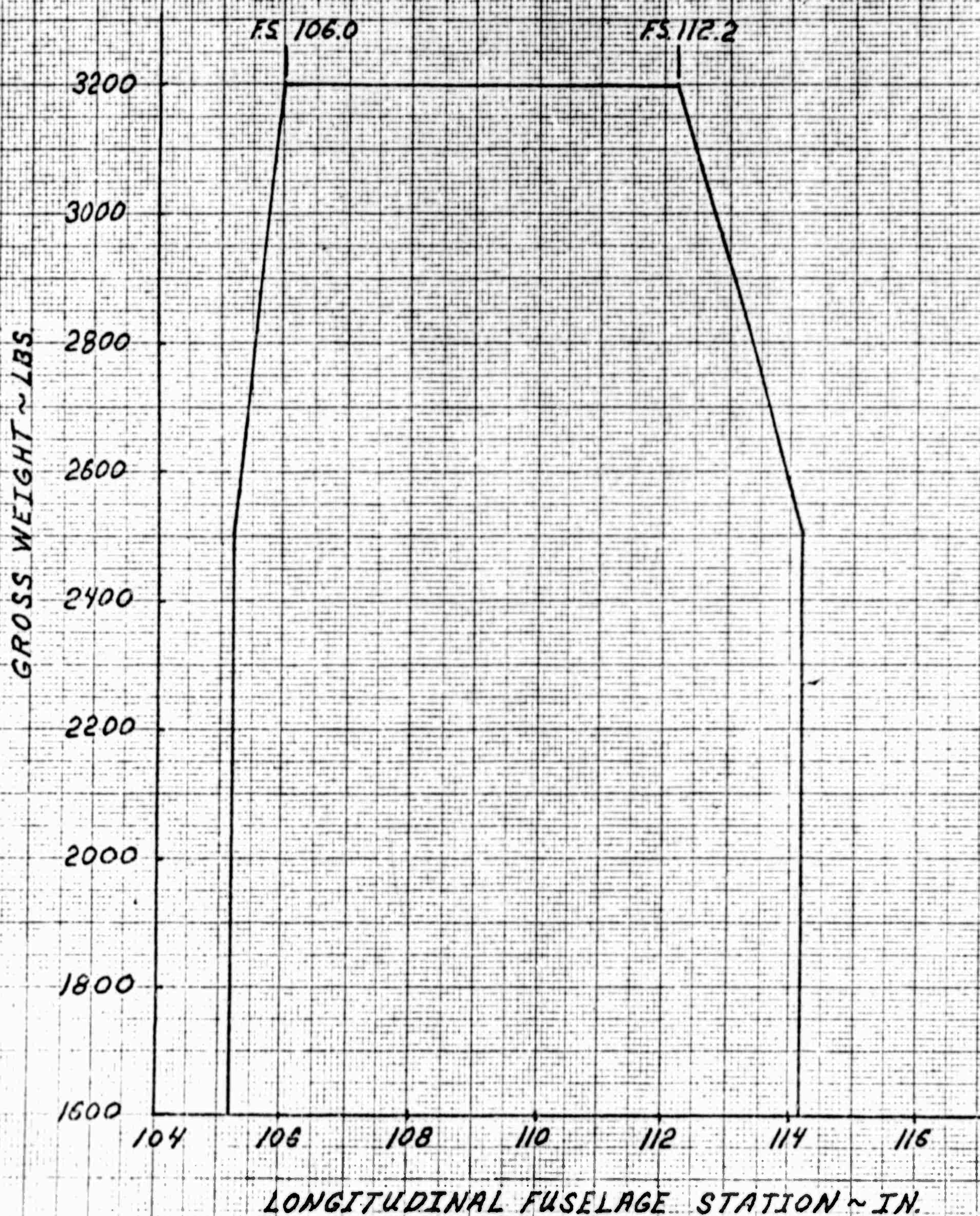


FIGURE 2

LIMIT LOAD FACTOR VS GROSS WEIGHT

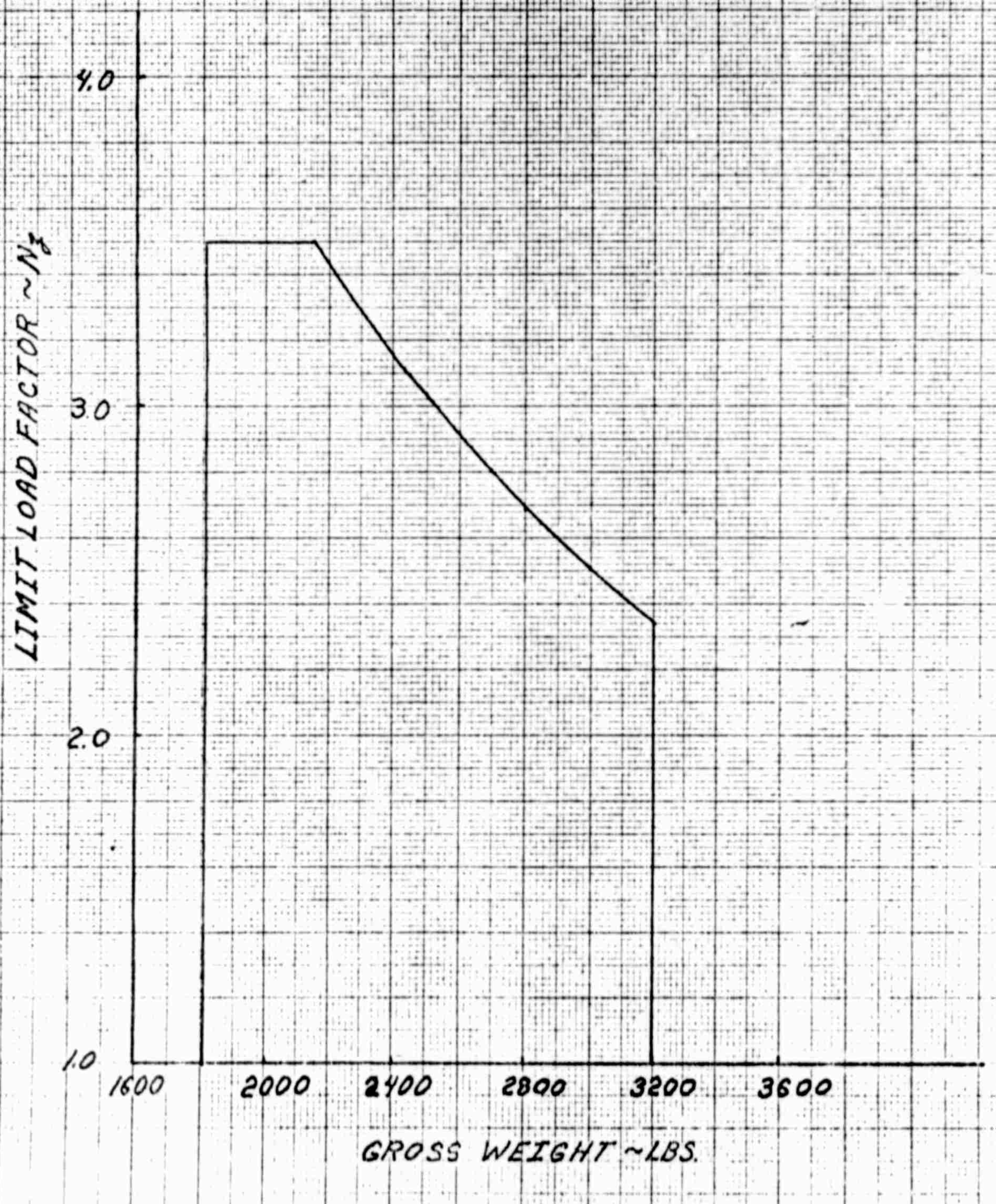
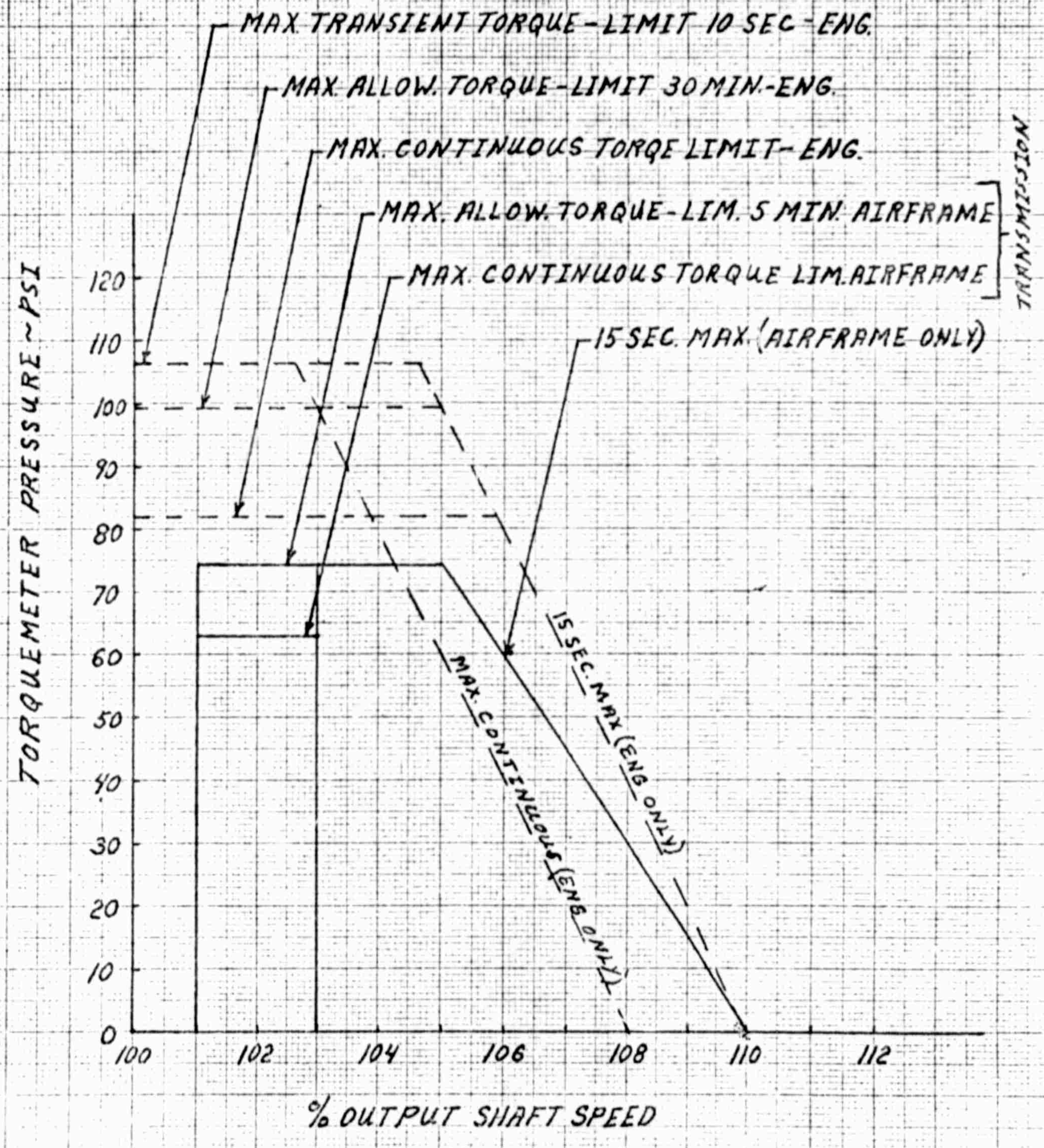


FIGURE 3
AIRFRAME AND ENGINE TORQUE AND OUTPUT SHAFT SPEED LIMITS



APPENDIX C. TEST INSTRUMENTATION

The instrumentation installed for this test is listed below:

Pilot and Engineer Panel

Airspeed (boom system)
Altitude (boom system)
Free air temperature
Rotor speed
Engine torque pressure
Longitudinal control position
Lateral control position
Directional control position
Collective control position
Fuel-used indicator
Oscillograph correlation counter

Oscillograph

Throttle position
Rotor speed
Engine torque pressure
Collective control position
Directional control position
Yaw attitude
Yaw rate
Lateral control position
Roll attitude
Roll rate
Longitudinal control position
Pitch attitude
Pitch rate
Engineer event

APPENDIX D. TEST DATA

INDEX

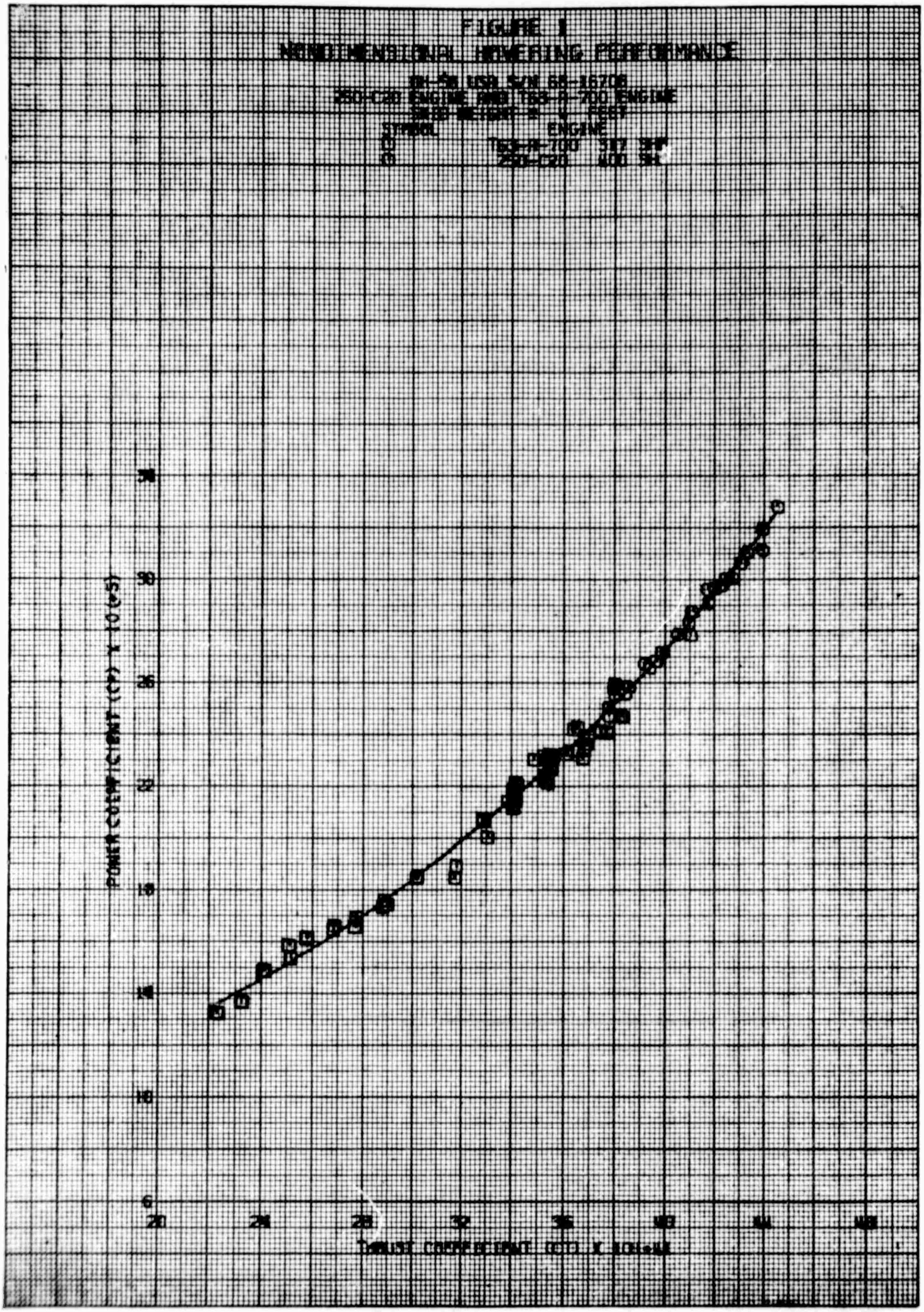


FIGURE 1
NONDIMENSIONAL HOVERING PERFORMANCE

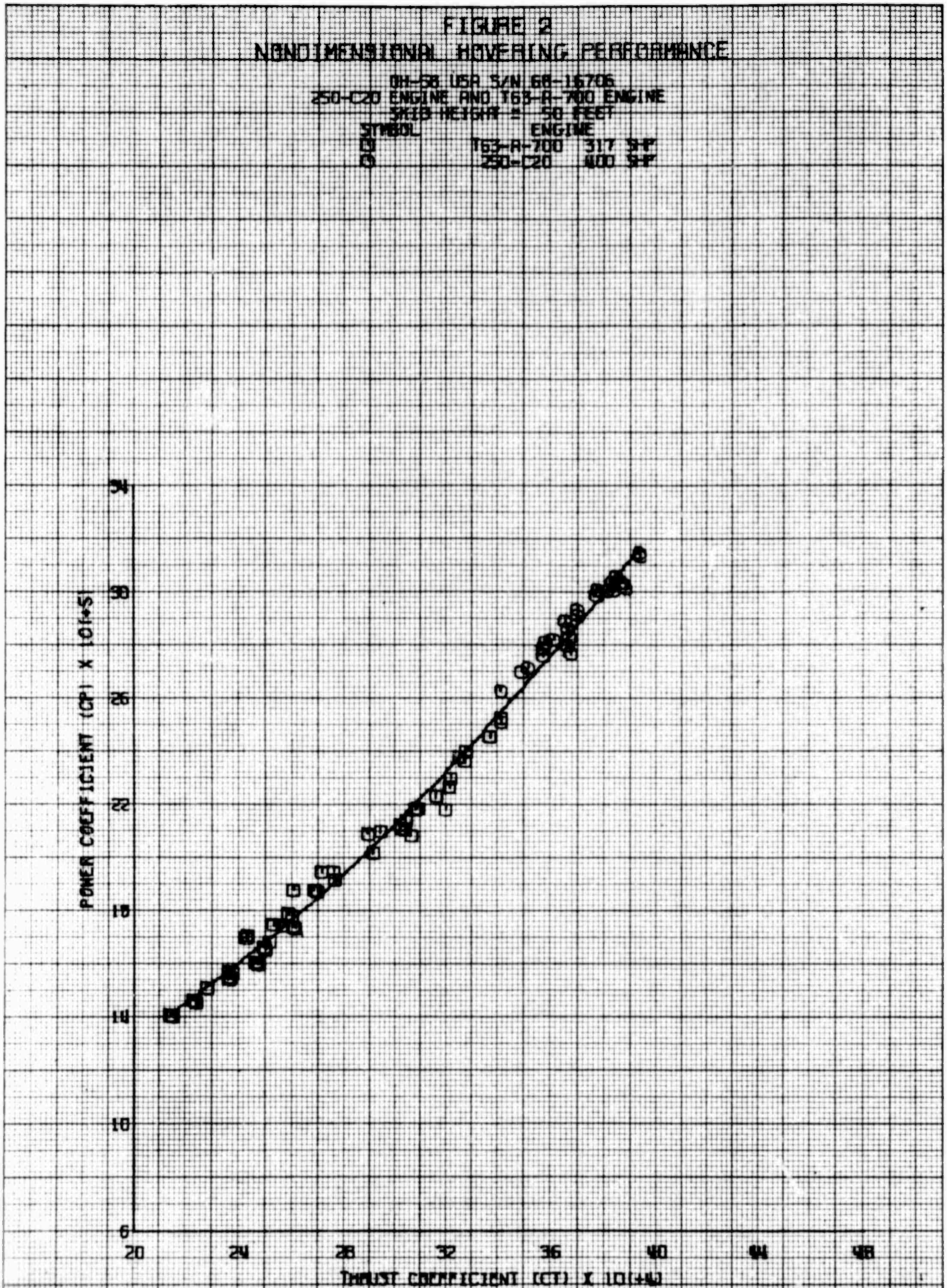


FIGURE 2
NONDIMENSIONAL HOVERING PERFORMANCE
OH-58 USA S/N 68-16706
250-C20 ENGINE AND T63-A-700 ENGINE
SKID HEIGHT = 50 FEET
SYMBOL
ENGINE
T63-A-700 317 SHP
250-C20 400 SHP
POWER COEFFICIENT (CP) X 10(+5)
34
30
26
22
18
14
10
6
20
24
28
32
36
40
44
48
THRUST COEFFICIENT (CT) X 10(+4)

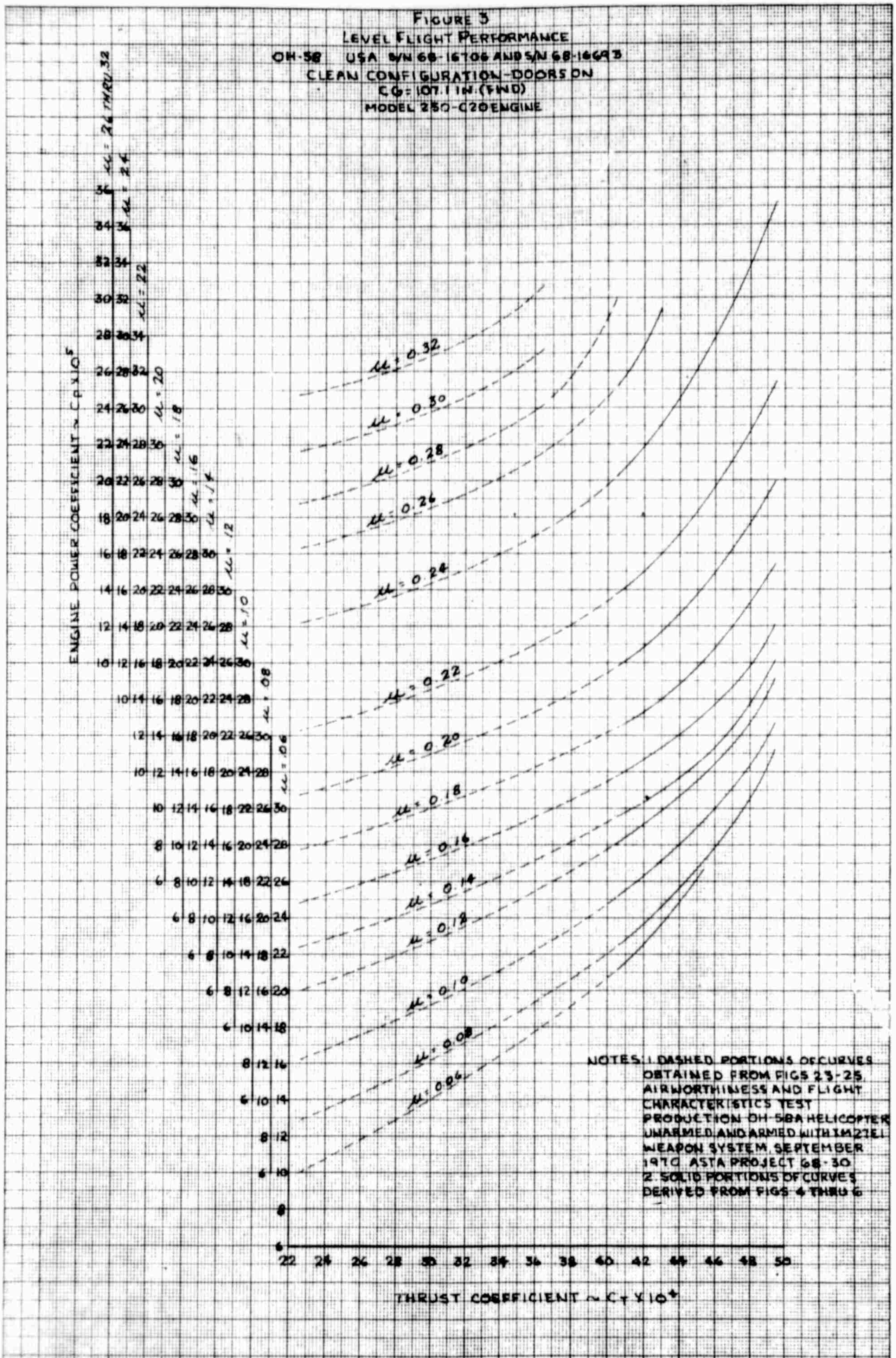


FIGURE 3
LEVEL FLIGHT PERFORMANCE
OH-58 USA S/N 68-16706 AND S/N 68-16693
CLEAN CONFIGURATION-DOORS ON
CG: 107.1 IN. (FWD)
MODEL 250-C20 ENGINE
ENGINE POWER COEFFICIENT ~ $C_P \times 10^5$
THRUST COEFFICIENT ~ $C_T \times 10^4$
$\mu = 0.32$
$\mu = 0.30$
$\mu = 0.28$
$\mu = 0.26$
$\mu = 0.24$
$\mu = 0.22$
$\mu = 0.20$
$\mu = 0.18$
$\mu = 0.16$
$\mu = 0.14$
$\mu = 0.12$
$\mu = 0.10$
$\mu = 0.08$
$\mu = 0.06$
NOTES: 1. DASHED PORTIONS OF CURVES OBTAINED FROM FIGS 23-25, AIRWORTHINESS AND FLIGHT CHARACTERISTICS TEST PRODUCTION OH-58A HELICOPTER UNARMED AND ARMED WITH XM27E1 WEAPON SYSTEM, SEPTEMBER 1970, ASTA PROJECT 68-30
2. SOLID PORTIONS OF CURVES DERIVED FROM FIGS 4 THRU 6

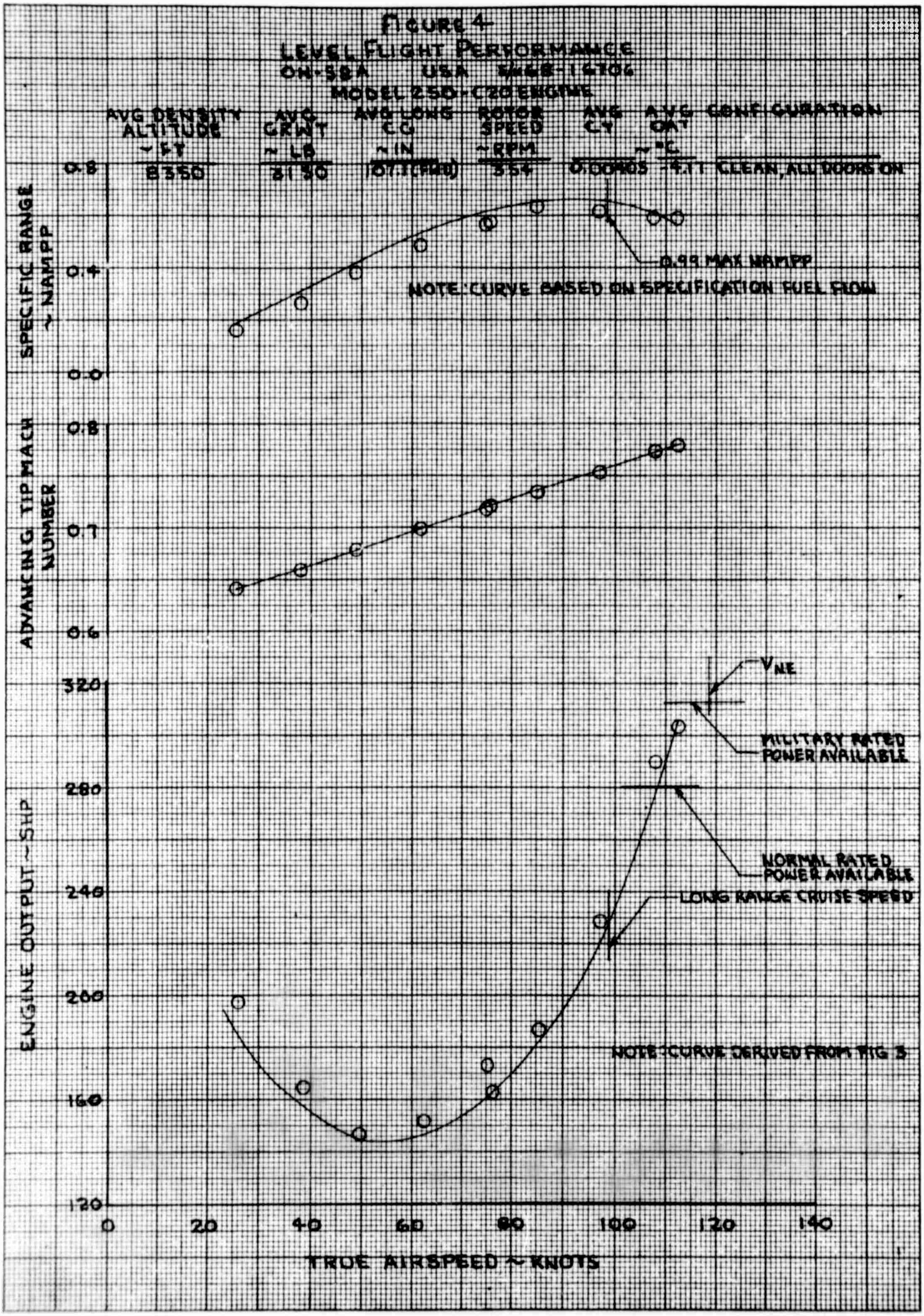
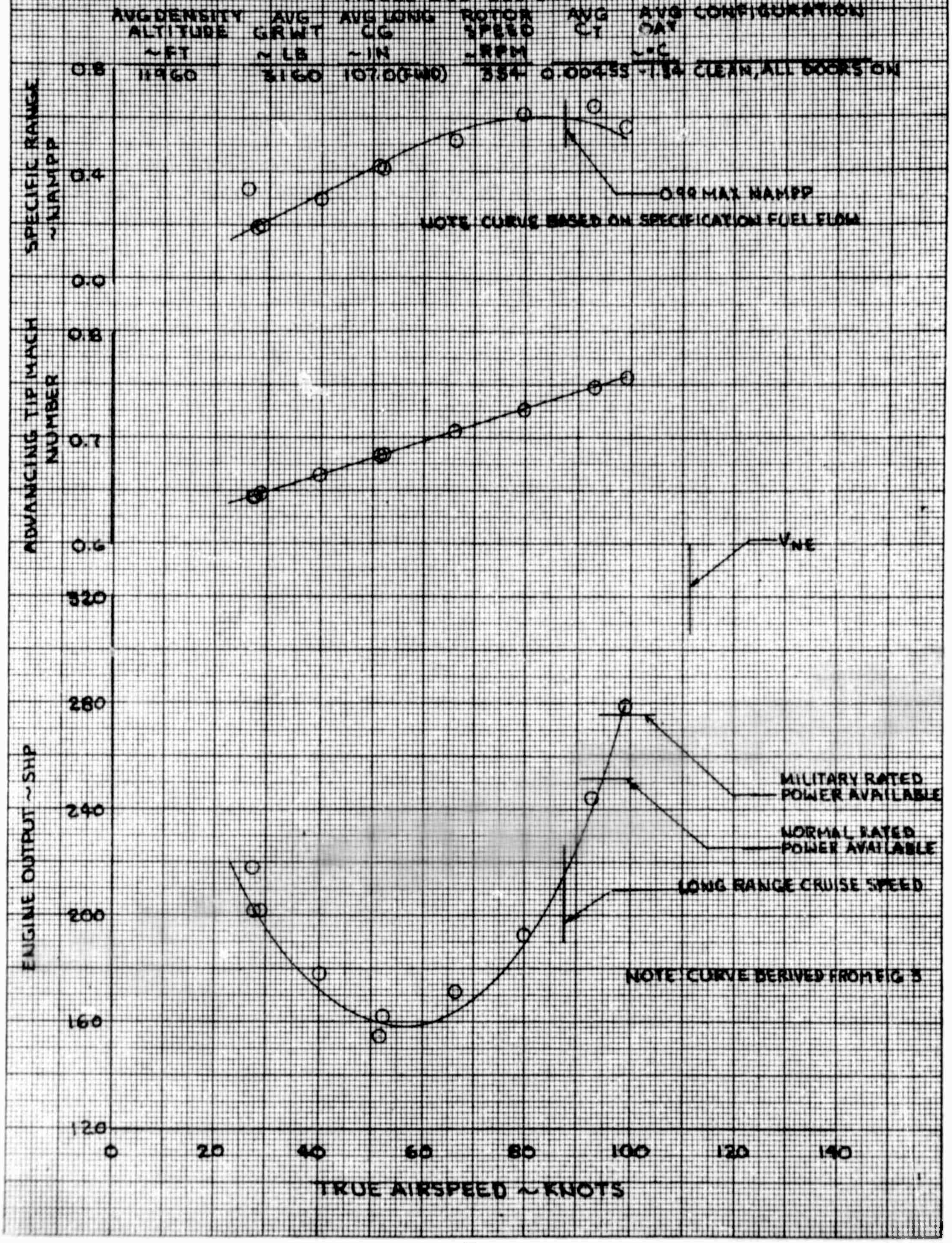


FIGURE 4
LEVEL FLIGHT PERFORMANCE
OH-58A USA S/N68-16706
MODEL 250-C20 ENGINE
AVG DENSITY ALTITUDE ~FT 8350
AVG GRWT ~LB 3150
AVG LONG CG ~IN 107.1(FWD)
ROTOR SPEED ~RPM 354
AVG CT 0.00405
AVG OAT ~°C -4.1
CONFIGURATION CLEAN, ALL DOORS ON
SPECIFIC RANGE ~ NAMPP
0.99 MAX NAMPP
NOTE: CURVE BASED ON SPECIFICATION FUEL FLOW
ADVANCING TIP MACH NUMBER
ENGINE OUTPUT ~ SHP
VNE
MILITARY RATED POWER AVAILABLE
NORMAL RATED POWER AVAILABLE
LONG RANGE CRUISE SPEED
NOTE: CURVE DERIVED FROM FIG 3
TRUE AIRSPEED ~ KNOTS

FIGURE 5
LEVEL FLIGHT PERFORMANCE
OH-58A USA S/N 68-16706
MODEL 250-C20 ENGINE



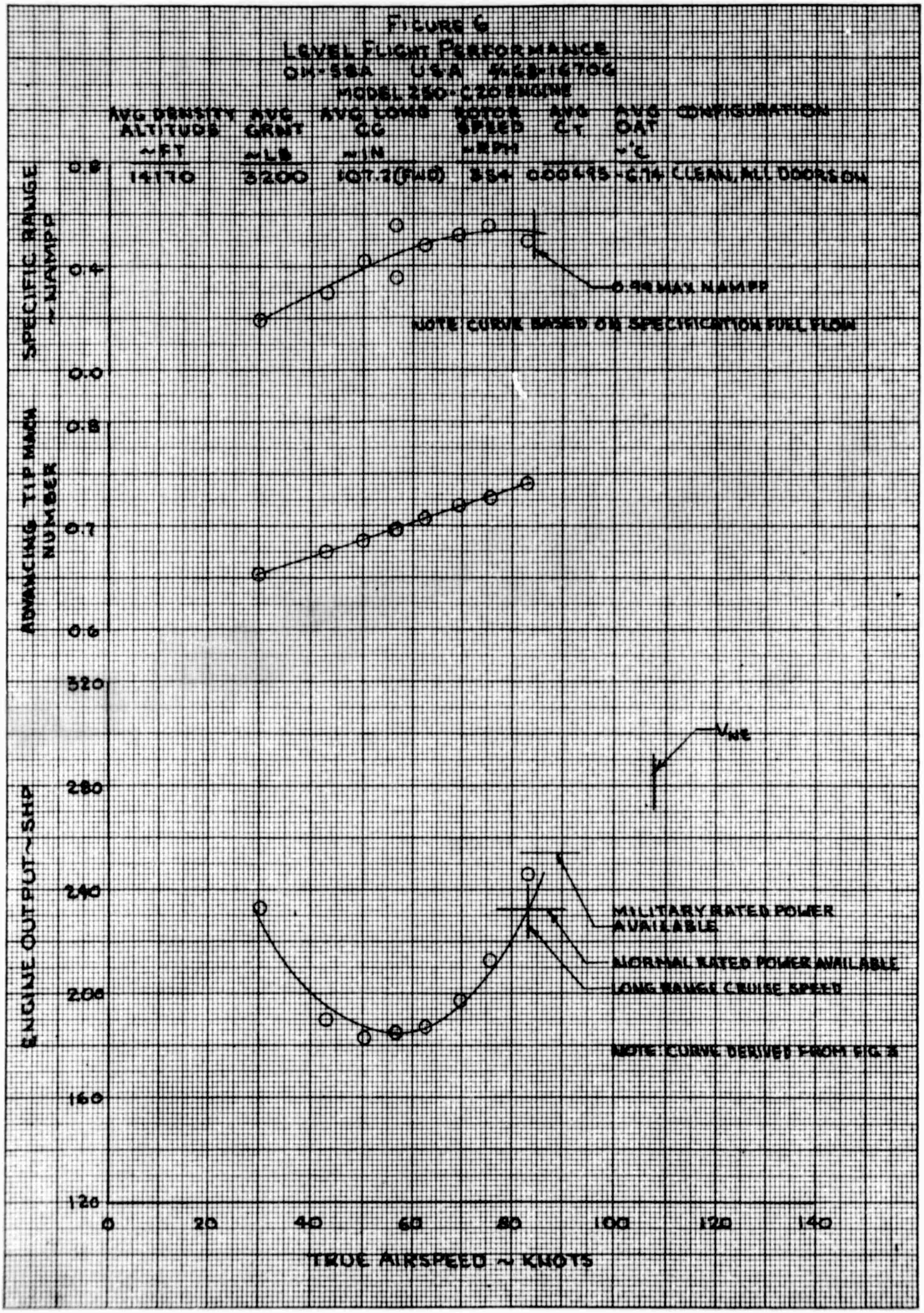


FIGURE 6
LEVEL FLIGHT PERFORMANCE
OH-58A USA S/N 68-16706
MODEL 250-C20 ENGINE
AVG DENSITY ALTITUDE ~FT
AVG GRWT ~LB
AVG LONG CG ~IN
ROTOR SPEED ~RPM
AVG CT
AVG OAT ~°C
CONFIGURATION
14170
3200
107.2(FWD)
354
0.00495
-6.14
CLEAN, ALL DOORS ON
SPECIFIC RANGE ~ NAMPP
0.99 MAX NAMPP
NOTE: CURVE BASED ON SPECIFICATION FUEL FLOW
ADVANCING TIP MACH NUMBER
ENGINE OUTPUT ~ SHP
MILITARY RATED POWER AVAILABLE
NORMAL RATED POWER AVAILABLE
LONG RANGE CRUISE SPEED
NOTE: CURVE DERIVED FROM FIG 3
TRUE AIRSPEED ~ KNOTS

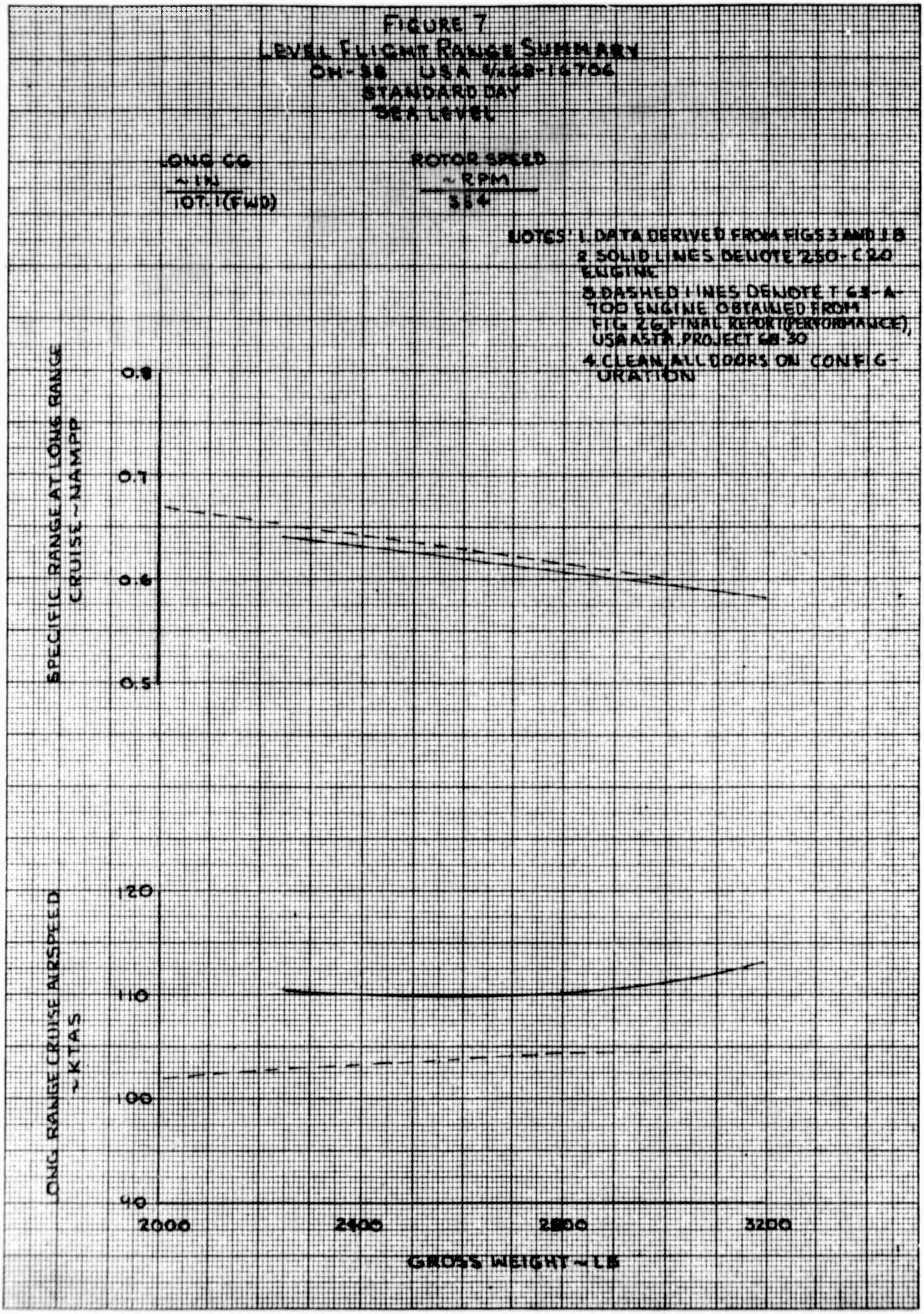


FIGURE 7
LEVEL FLIGHT RANGE SUMMARY
OH-58 USA S/N 68-16706
STANDARD DAY
SEA LEVEL
LONG CG ~IN
107.1 (FWD)
ROTOR SPEED ~RPM
354
NOTES: 1. DATA DERIVED FROM FIGS 3 AND 18
2. SOLID LINES DENOTE 250-C20 ENGINE
3. DASHED LINES DENOTE T63-A-700 ENGINE OBTAINED FROM FIG 26, FINAL REPORT (PERFORMANCE), USAASTA, PROJECT 68-30
4. CLEAN, ALL DOORS ON CONFIGURATION
SPECIFIC RANGE AT LONG RANGE CRUISE ~NAMPP
0.8
0.7
0.6
0.5
LONG RANGE CRUISE AIRSPEED ~KTAS
120
110
100
90
2000
2400
2800
3200
GROSS WEIGHT ~LB

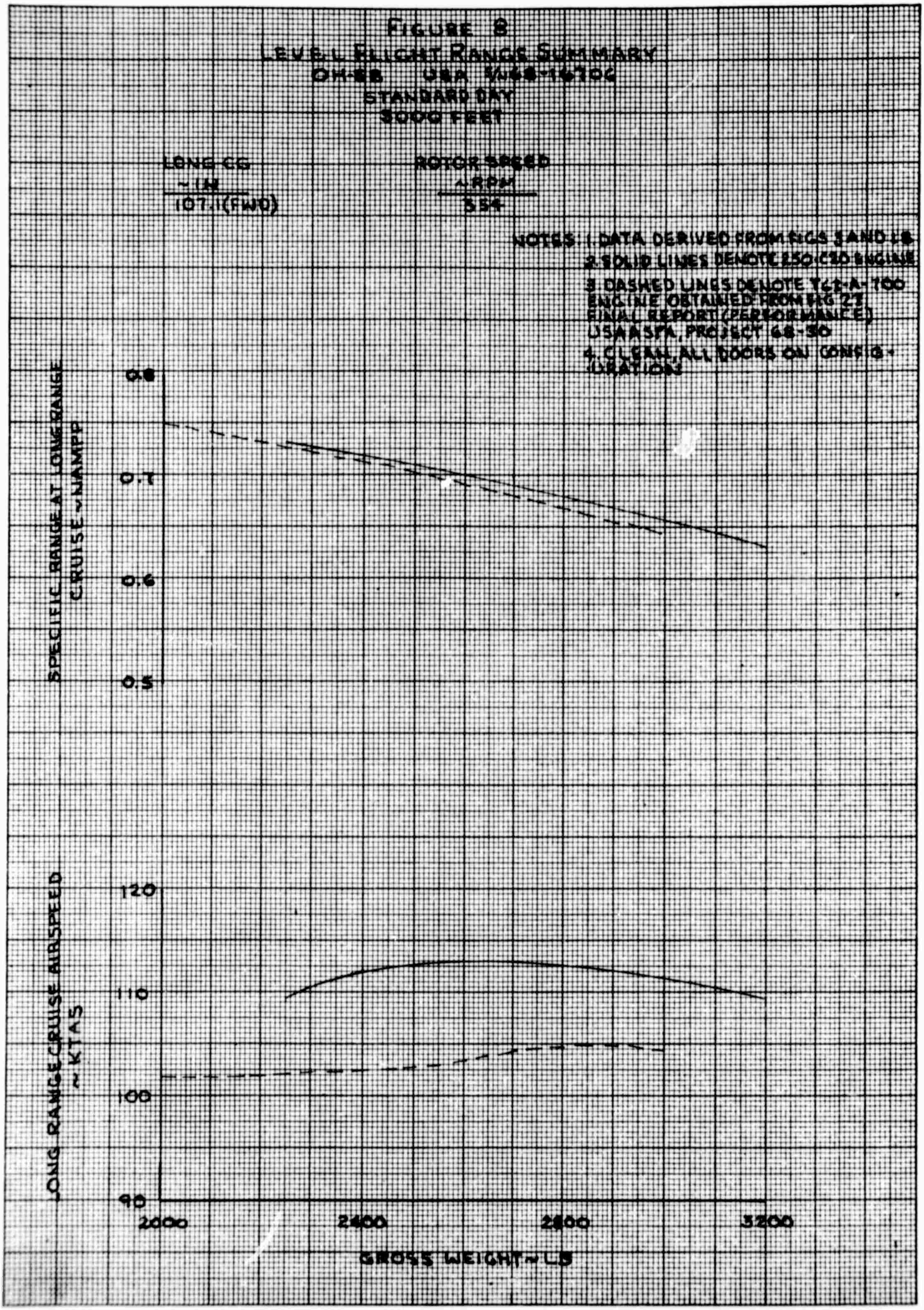


FIGURE 8
LEVEL FLIGHT RANGE SUMMARY
OH-58 USA S/N 68-16704
STANDARD DAY
5000 FEET
LONG CG ~IN
107.1 (FWD)
ROTOR SPEED ~RPM
354
NOTES: 1. DATA DERIVED FROM FIGS 3 AND 18
2. SOLID LINES DENOTE 250-C20 ENGINE
3. DASHED LINES DENOTE T63-A-700 ENGINE OBTAINED FROM FIG 23, FINAL REPORT (PERFORMANCE) USAASTA, PROJECT 68-30
4. CLEAN, ALL DOORS ON CONFIGURATION
SPECIFIC RANGE AT LONG RANGE CRUISE ~NAMPP
0.8
0.7
0.6
0.5
LONG RANGE CRUISE AIRSPEED ~KTAS
120
110
100
90
2000
2400
2800
3200
GROSS WEIGHT ~LB

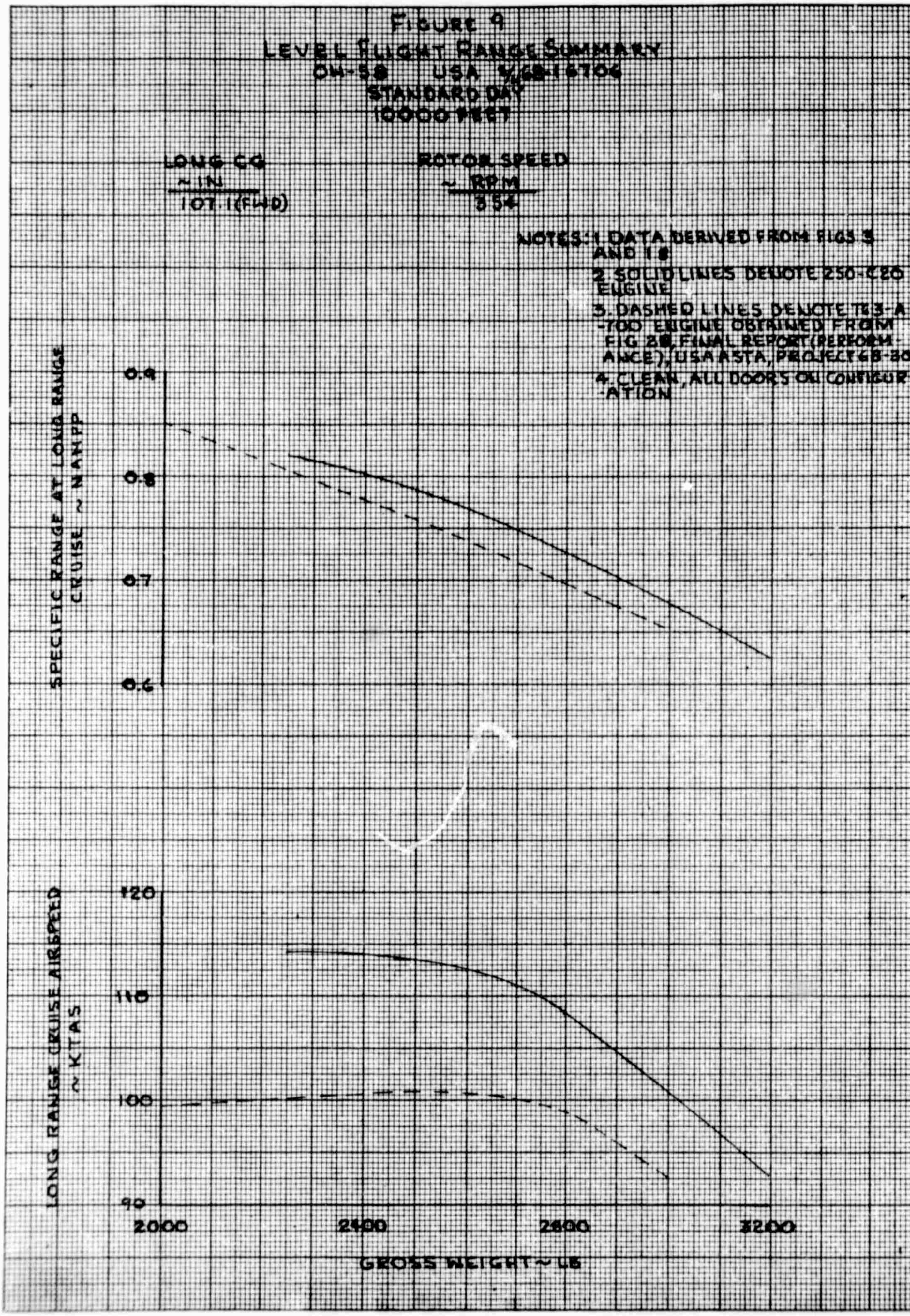


FIGURE 9
LEVEL FLIGHT RANGE SUMMARY
OH-58 USA S/N 68-16706
STANDARD DAY
10000 FEET
LONG CG ~IN
107.1(FWD)
ROTOR SPEED ~ RPM
354
NOTES: 1. DATA DERIVED FROM FIGS 3 AND 18
2. SOLID LINES DENOTE 250-C20 ENGINE
3. DASHED LINES DENOTE T63-A-700 ENGINE OBTAINED FROM FIG 28, FINAL REPORT (PERFORMANCE), USAASTA, PROJECT 68-30
4. CLEAN, ALL DOORS ON CONFIGURATION
SPECIFIC RANGE AT LONG RANGE CRUISE ~ NAMPP
0.9
0.8
0.7
0.6
LONG RANGE CRUISE AIRSPEED ~ KTAS
120
110
100
90
2000
2400
2800
3200
GROSS WEIGHT ~ LB

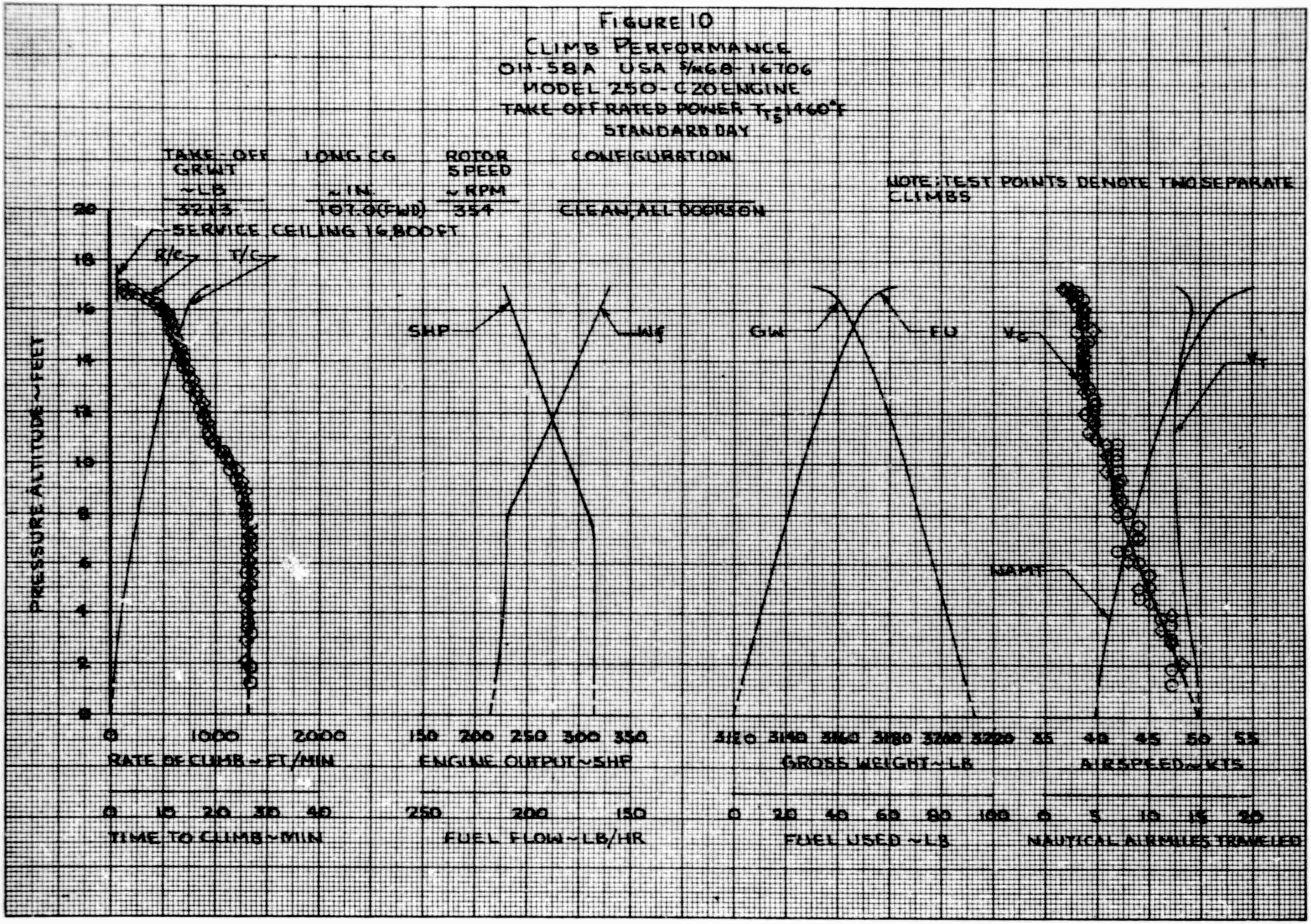
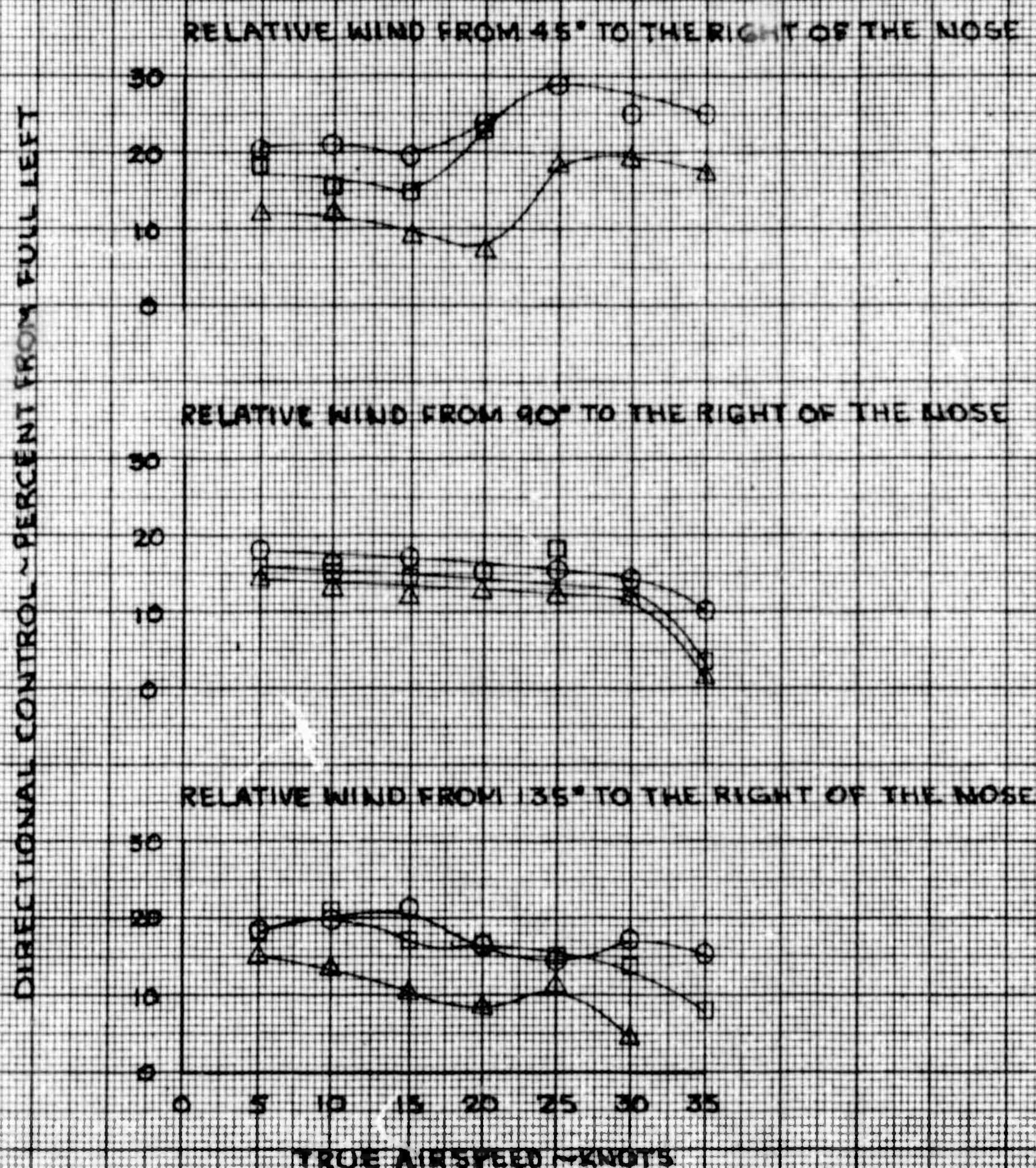


FIGURE 10
CLIMB PERFORMANCE
OH-58A USA S/N 68-16706
MODEL 250-C20 ENGINE
TAKE-OFF RATED POWER T_{T_5}=1460°F
STANDARD DAY
TAKE-OFF GRWT ~LB 3213
LONG CG ~IN. 107.0(FWD)
ROTOR SPEED ~RPM 354
CONFIGURATION CLEAN, ALL DOORS ON
NOTE: TEST POINTS DENOTE TWO SEPARATE CLIMBS
SERVICE CEILING 16,800 FT
R/C
T/C
SHP
Wf
GW
FU
V_c
NAMT
PRESSURE ALTITUDE ~ FEET
RATE OF CLIMB ~ FT/MIN
TIME TO CLIMB ~ MIN
ENGINE OUTPUT ~ SHP
FUEL FLOW ~ LB/HR
GROSS WEIGHT ~ LB
FUEL USED ~ LB
AIRSPEED ~ KTS
NAUTICAL AIRMILES TRAVELED

FIGURE 11
RIGHT SIDEWARD FLIGHT
OH-58 USA S/N 68-16706
MODEL 250-C20 ENGINE

SYMBOL	AVG DENSITY ALTITUDE ~ FT	AVG GR WT ~ LB	AVG OAT ~ °C	AVG LONG CG ~ IN.	ROTOR SPEED ~ RPM	AVG C_T
○	11340	2460	13.6	108.6 (MID)	353.5	0.00346
□	9920	2680	-1.9	109.4 (MID)	354	0.00359
△	10640	2795	3.7	109.4 (MID)	354	0.00392

NOTE: TOTAL DIRECTIONAL CONTROL TRAVEL IS 6.86 INCHES



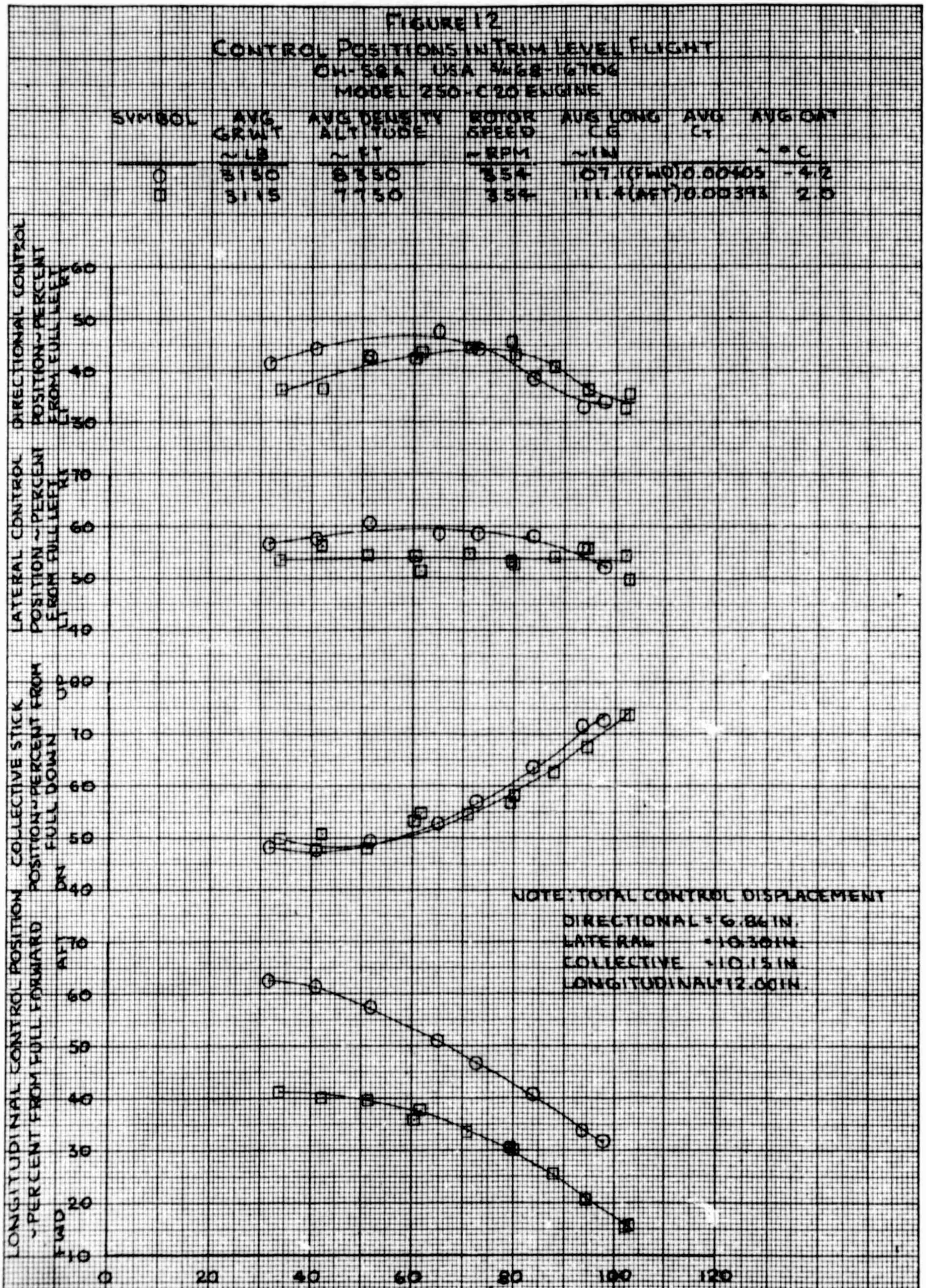


FIGURE 12
CONTROL POSITIONS IN TRIM LEVEL FLIGHT
OH-58A USA S/N 68-16706
MODEL 250-C20 ENGINE
SYMBOL
AVG GR WT ~LB
AVG DENSITY ALTITUDE ~FT
ROTOR SPEED ~RPM
AVG LONG CG ~IN
AVG C_T
AVG OAT ~°C
○ 3150 8350 354 107.1(FWD) 0.00405 -4.2
□ 3115 7750 354 111.4(AFT) 0.00393 2.0
DIRECTIONAL CONTROL POSITION ~ PERCENT FROM FULL LEFT
LT RT
LATERAL CONTROL POSITION ~ PERCENT FROM FULL LEFT
LT RT
COLLECTIVE STICK POSITION ~ PERCENT FROM FULL DOWN
DN UP
LONGITUDINAL CONTROL POSITION ~ PERCENT FROM FULL FORWARD
FWD AFT
NOTE: TOTAL CONTROL DISPLACEMENT
DIRECTIONAL = 6.86 IN.
LATERAL = 10.30 IN.
COLLECTIVE = 10.15 IN.
LONGITUDINAL = 12.00 IN.
CALIBRATED AIRSPEED ~ KNOTS

FIGURE 13
CONTROL POSITIONS IN TRIM LEVEL FLIGHT
OH-58A USA S/N 68-16706
MODEL 250-C20 ENGINE

SYMBOL	AVG GR WT ~ LB	AVG DENSITY ALTITUDE ~ FT	ROTOR SPEED ~ RPM	AVG LONG CG ~ IN.	AVG C_T	AVG OAT ~ °C
○	3180	12000	354	107.0 (FWD)	0.00455	-1.3
□	3200	14420	354	107.2 (FWD)	0.00495	-6.7

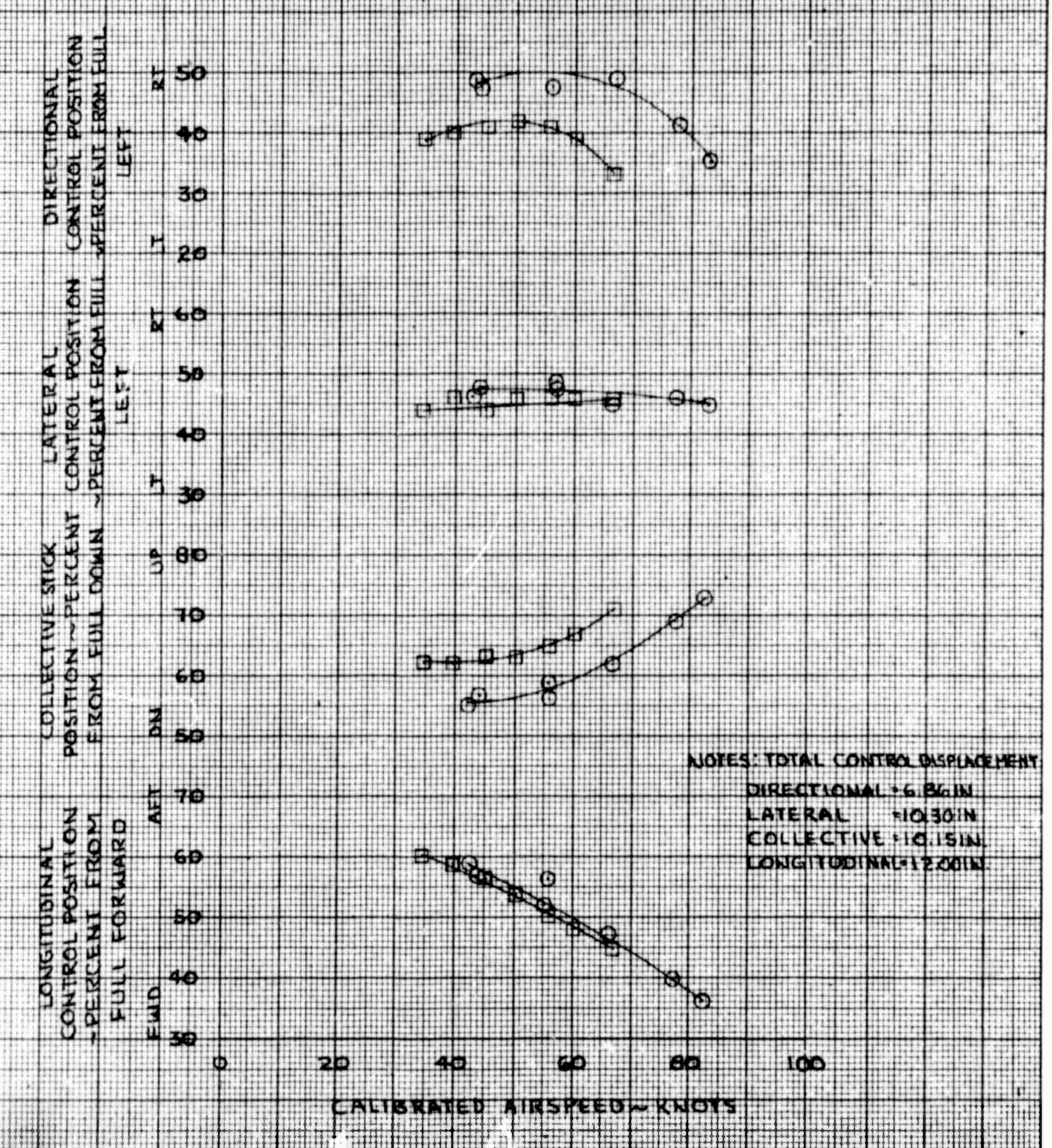
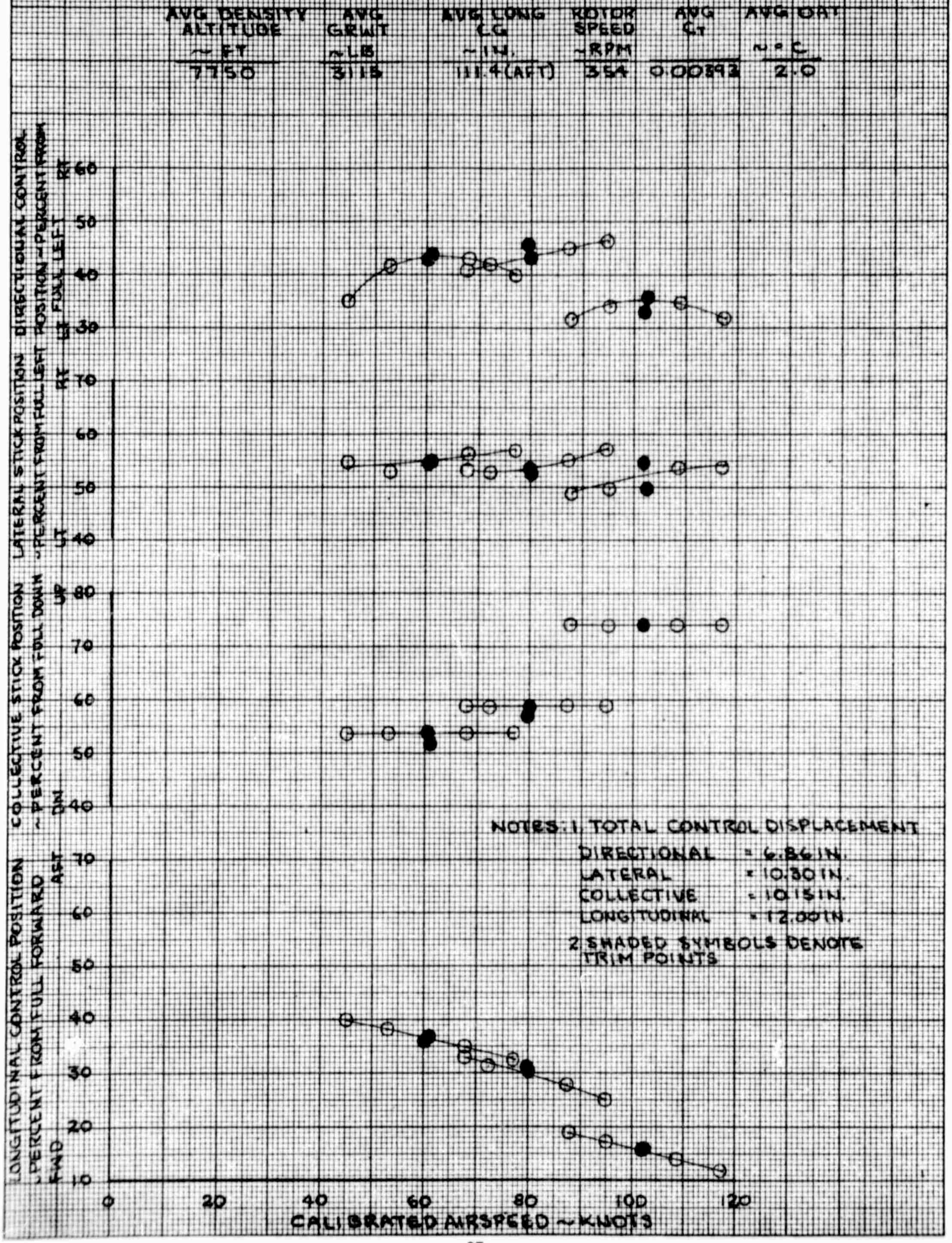


FIGURE 14
STATIC LONGITUDINAL COLLECTIVE FIXED STABILITY
OH-58A USA S/N 68-16706
MODEL 250-C20 ENGINE



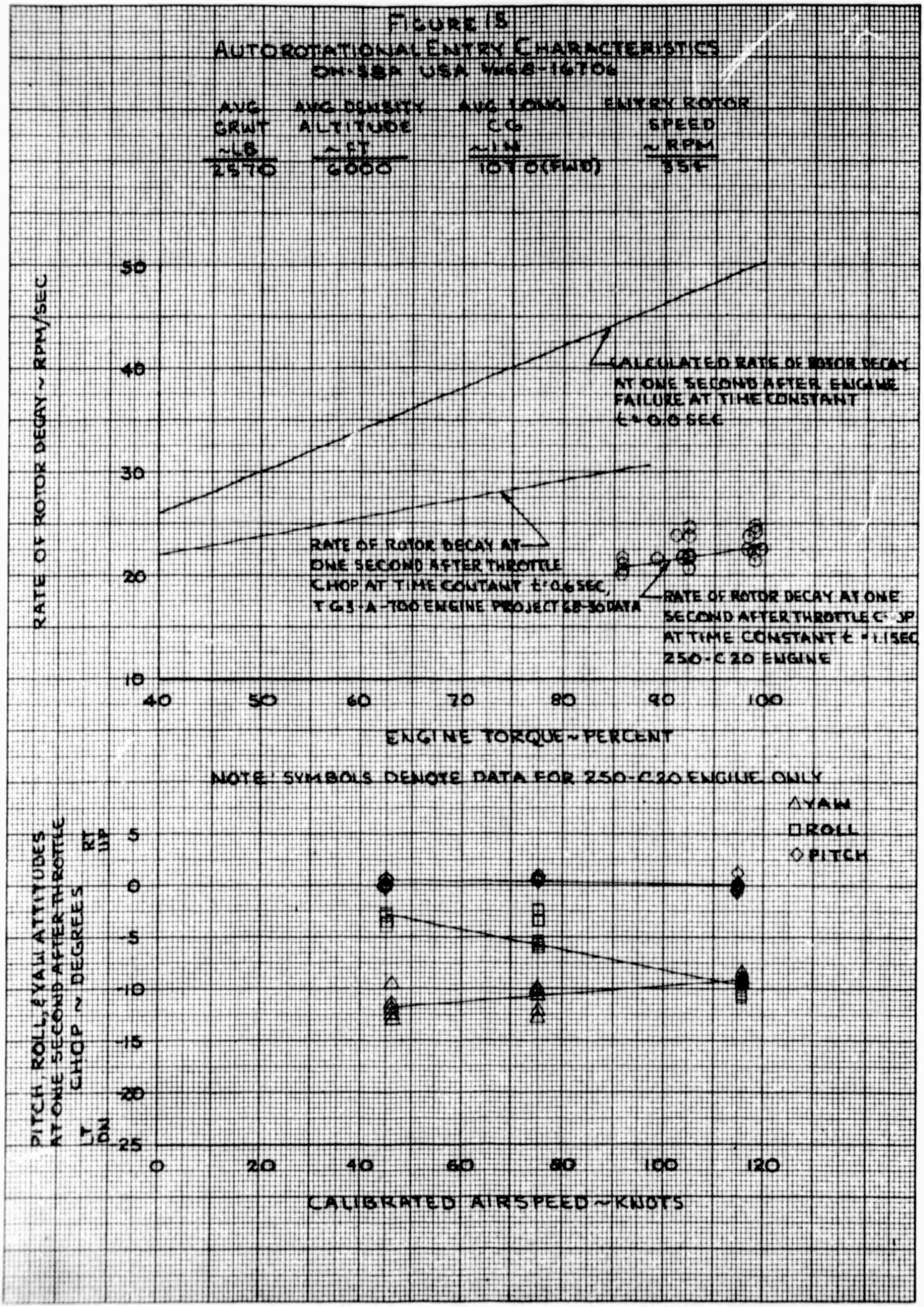


FIGURE 15
AUTOROTATIONAL ENTRY CHARACTERISTICS
AVG GRWT ~LB
2570
AVG DENSITY ALTITUDE ~FT
6000
AVG LONG CG ~IN
ENTRY ROTOR SPEED ~RPM
RATE OF ROTOR DECAY ~ RPM/SEC
CALCULATED RATE OF ROTOR DECAY AT ONE SECOND AFTER ENGINE FAILURE AT TIME CONSTANT
RATE OF ROTOR DECAY AT ONE SECOND AFTER THROTTLE CHOP AT TIME CONSTANT
RATE OF ROTOR DECAY AT ONE SECOND AFTER THROTTLE
250-C20 ENGINE
ENGINE TORQUE ~ PERCENT
NOTE: SYMBOLS DENOTE DATA FOR 250-C20 ENGINE ONLY
△YAW
□ROLL
◇PITCH
PITCH, ROLL, & YAW ATTITUDES AT ONE SECOND AFTER THROTTLE CHOP ~ DEGREES
RT UP
LT DN
CALIBRATED AIRSPEED ~ KNOTS

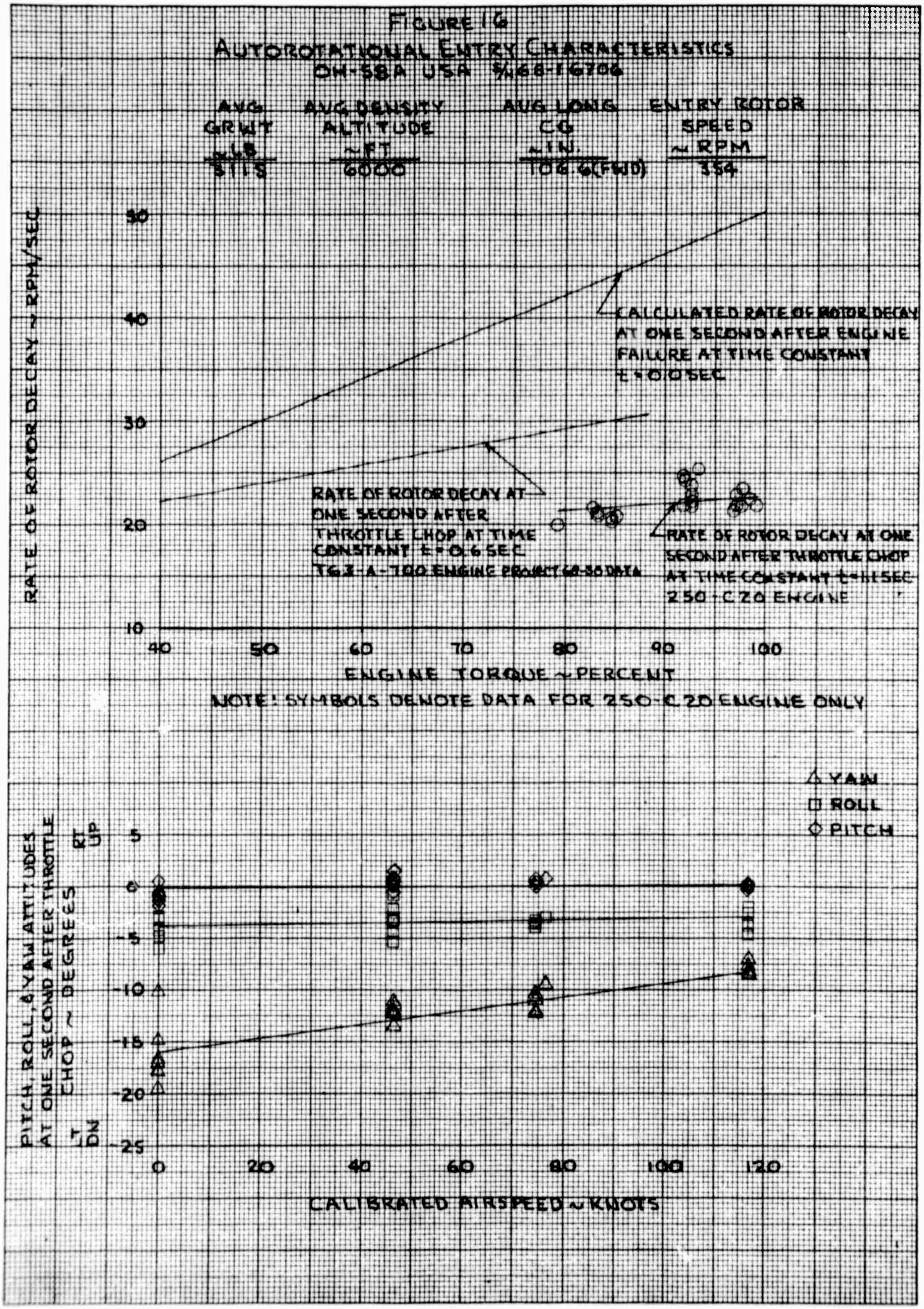
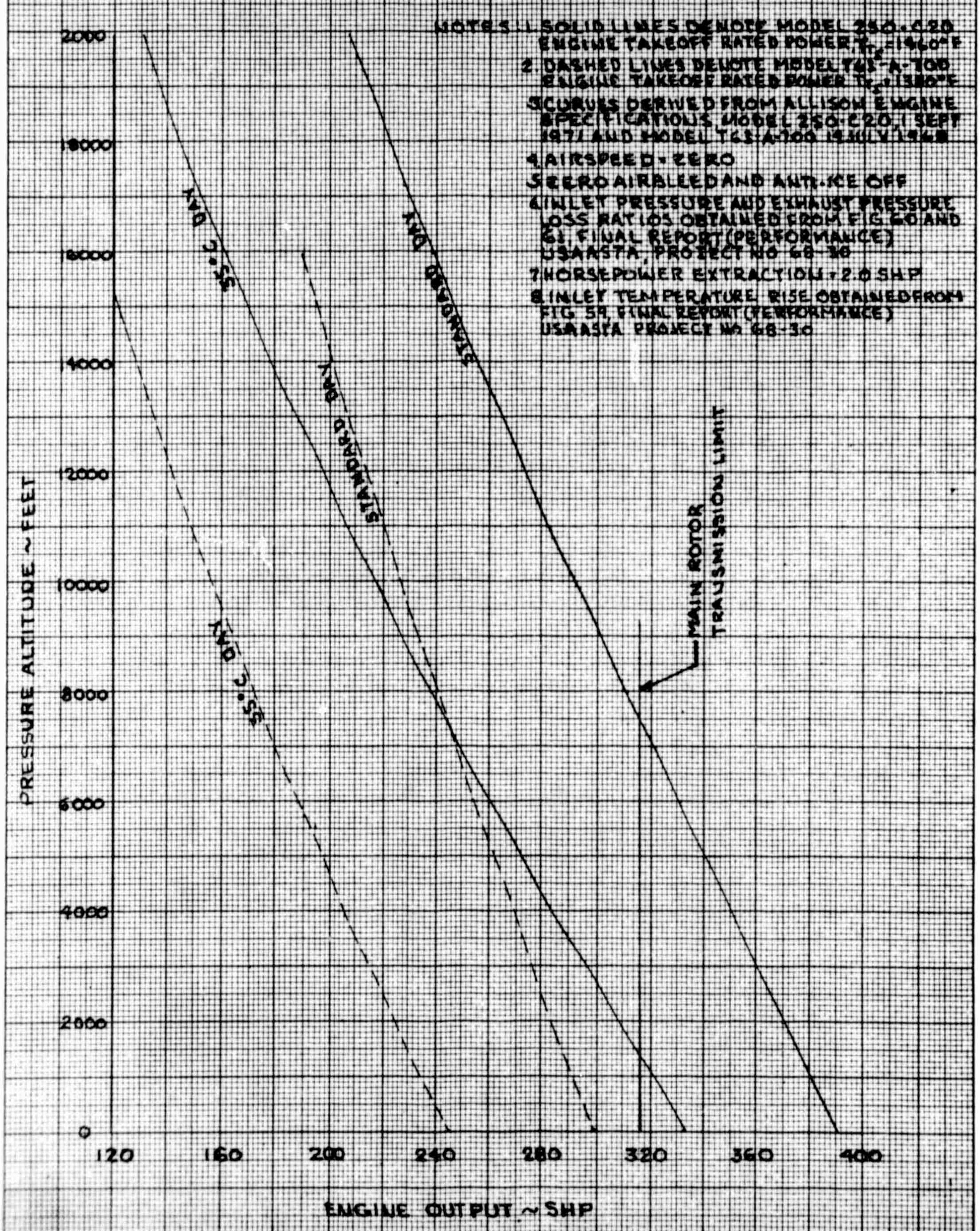


FIGURE 16
AUTOROTATIONAL ENTRY CHARACTERISTICS
OH-58A USA S/N 68-16706
AVG GRWT ~LB 3115
AVG DENSITY ALTITUDE ~FT 6000
AVG LONG CG ~IN. 106.6(FWD)
ENTRY ROTOR SPEED ~RPM 354
RATE OF ROTOR DECAY ~ RPM/SEC
CALCULATED RATE OF ROTOR DECAY AT ONE SECOND AFTER ENGINE FAILURE AT TIME CONSTANT t = 0.0 SEC
RATE OF ROTOR DECAY AT ONE SECOND AFTER THROTTLE CHOP AT TIME CONSTANT t = 0.6 SEC T63-A-700 ENGINE PROJECT 68-30 DATA
RATE OF ROTOR DECAY AT ONE SECOND AFTER THROTTLE CHOP AT TIME CONSTANT t = 1.1 SEC 250-C20 ENGINE
ENGINE TORQUE ~ PERCENT
NOTE: SYMBOLS DENOTE DATA FOR 250-C20 ENGINE ONLY
YAW
ROLL
PITCH
PITCH, ROLL, & YAW ATTITUDES AT ONE SECOND AFTER THROTTLE CHOP ~ DEGREES
RT UP
LT DN
CALIBRATED AIRSPEED ~ KNOTS

FIGURE 17
SHAFT HORSEPOWER AVAILABLE COMPARISON
MODEL 250-C20 AND T63-A-700 ENGINES
OH-58A



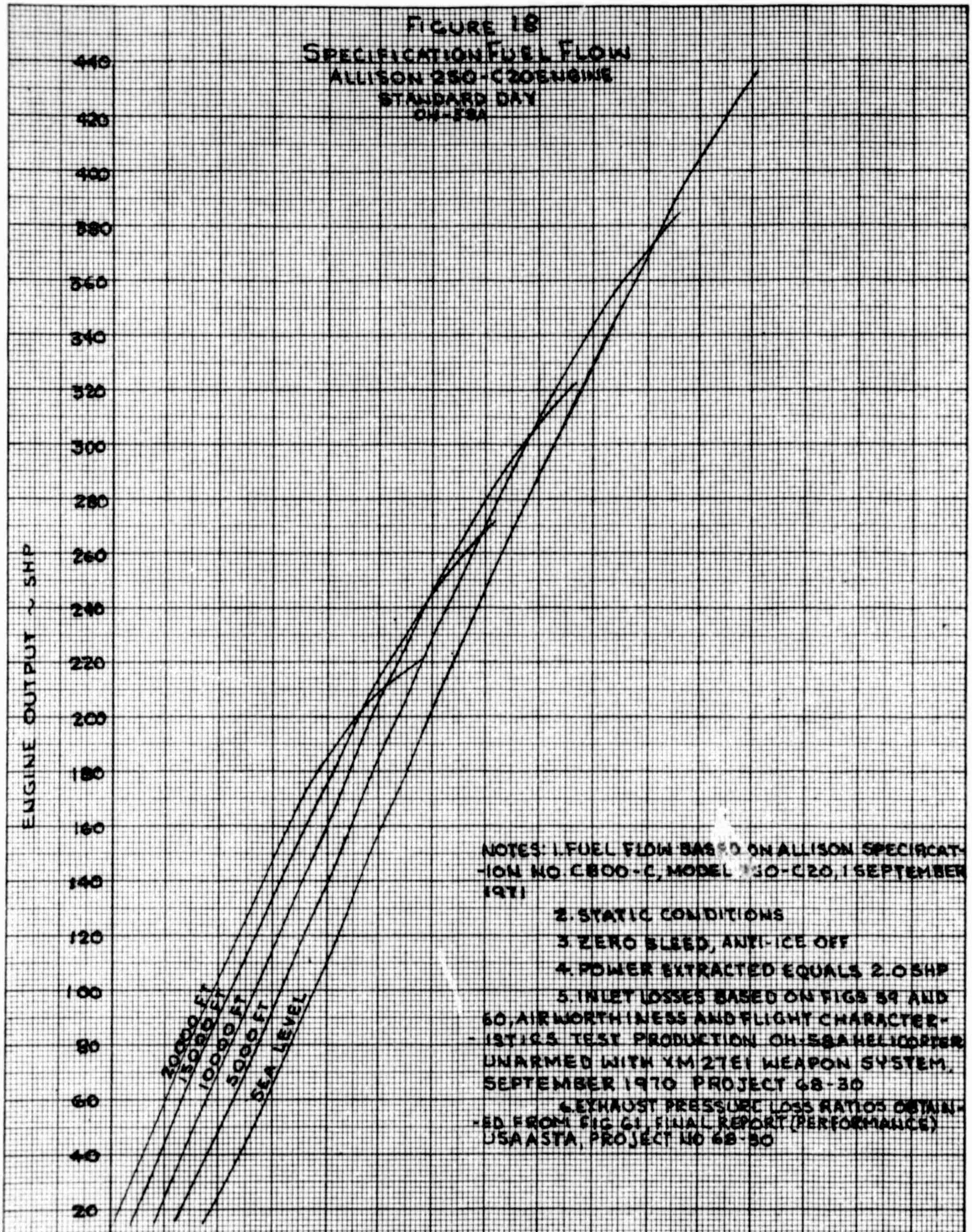


FIGURE 18
SPECIFICATION FUEL FLOW
ALLISON 250-C20 ENGINE
STANDARD DAY
OH-58A
ENGINE OUTPUT ~ SHP
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
FUEL FLOW ~ LB/HR
40
80
120
160
200
240
280
320
20000 FT
15000 FT
10000 FT
5000 FT
SEA LEVEL
NOTES: 1. FUEL FLOW BASED ON ALLISON SPECIFICATION NO C800-C, MODEL 250-C20, 1 SEPTEMBER 1971
2. STATIC CONDITIONS
3. ZERO BLEED, ANTI-ICE OFF
4. POWER EXTRACTED EQUALS 2.0 SHP
5. INLET LOSSES BASED ON FIGS 59 AND 60, AIRWORTHINESS AND FLIGHT CHARACTERISTICS TEST PRODUCTION OH-58A HELICOPTER UNARMED WITH XM 27E1 WEAPON SYSTEM, SEPTEMBER 1970 PROJECT 68-30
6. EXHAUST PRESSURE LOSS RATIOS OBTAINED FROM FIG 61, FINAL REPORT (PERFORMANCE) USAASTA, PROJECT NO 68-30

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) US ARMY AVIATION SYSTEMS TEST ACTIVITY EDWARDS AIR FORCE BASE, CALIFORNIA 93523	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE

EVALUATION OF THE OH-58A HELICOPTER WITH AN ALLISON 250-C20 ENGINE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

FINAL REPORT 24 June 1971 through 7 January 1972

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6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
DECEMBER 1972	52	7

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) USAASTA PROJECT NO. 71-24
b. PROJECT NO. AVSCOM PROJECT NO. 71-24	
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	NA

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY US ARMY AVIATION SYSTEMS COMMAND ATTN: AMSAV-EF PO BOX 209, ST. LOUIS, MISSOURI 63166

13. ABSTRACT

The United States Army Aviation Systems Test Activity conducted a limited performance and handling qualities evaluation of the Bell Helicopter Company model OH-58A helicopter with an Allison 250-C20 engine installed. The evaluation was conducted at Edwards Air Force Base, and Bishop, California, during the period 22 September 1971 to 7 January 1972. Twenty-five flights, 21.2 productive test hours, were required for the evaluation. Test results obtained with the Allison 250-C20 engine were compared with those previously obtained with the standard T63-A-700 engine. The primary performance improvement noted was an increase in out-of-ground-effect hover ceiling at a 3000-pound gross weight to 10,000 feet from 4600 feet. The long-range cruise airspeed was increased to 111 knots true airspeed from 104 knots true airspeed at a 5000-foot density altitude and a 3000-pound gross weight. The increased engine power did not significantly increase the service ceiling over the basic OH-58A at identical gross weights. One shortcoming, insufficient left directional control at 35 knots true airspeed in right sideward flight, was noted. Within the scope of the test, the performance of the OH-58A helicopter with the Allison 250-C20 engine was improved over the basic OH-58A helicopter. Handling qualities were essentially unchanged.

DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

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Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Limited performance and handling qualities evaluation						
Bell Helicopter Company model OH-58A helicopter						
Allison 250-C20 engine						
Increase in out-of-ground-effect hover ceiling						
Long-range cruise airspeed increased						
Insufficient left directional control						
Performance was improved						